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Australian Institute of Criminology

Understanding bushfire: trends in deliberate vegetation fires in Australia

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Technical and Background Paper

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Introduction

Background and purpose of this report

Australia is the most fire-prone continent and country on Earth. In any one year numerous fires burn hundreds of thousands to millions of hectares of savannas, other grasslands, bushland and forests. While fire is an essential component of many ecosystems, a natural instrument for maintaining biodiversity and hence a tool that enables many species to survive, not all fires are natural or beneficial. Humans play a significant role in modifying the timing, frequency and size of bushfires, in some cases to the detriment of the environment and to the endangerment of property and human life. While some human-caused fires are for the purposes of managing the environment, protecting human life and property, or the result of accidental actions, many fires occur through negligence, carelessness, mischievousness, or outright maliciousness, with little regard for either the environment or people who might be adversely affected. It is this latter group of fires – herein referred to as deliberate ignitions – that forms the central theme of this report.

Although a number of studies have documented the incidence of deliberate fires for isolated areas of Australia (see Willis 2004), there is a distinct lack of consolidated national data. As Willis (2004: 27) illustrated in his literature search on bushfire arson:

> In response to a question on notice in the Australian House of Representatives, which asked whether it was a fact that 70 per cent of bushfires are the result of arson, Dr Brendan Nelson, Minister for Education, Science and Training stated that the Department of Education, Science and Training did not have any statistical information on bushfires arising from arson (Hansard 2003). In response to the same question, Wilson Tuckey, Minister for Regional Services, Territories and Local Government was also unable to advise whether the suggested rate was correct, stating that while a significant proportion of bushfires are suspected to be due to arson, there is no consistent national approach to the collection and analysis of bushfire data (Hansard 2003).

This report represents the first concerted effort to establish **plausible** rates of illegal firesetting in vegetation across Australia. The term plausible is emphasised, as this is inherently an imprecise science. There are intrinsic difficulties in determining the causes of bushfires. In some cases there may be little evidence to confirm or deny whether a fire was deliberate, accidental or natural in origin. The relative isolation and concealment offered by bushland means there are few witnesses to the act. In many cases, firefighters or investigators will develop a suspicion that a fire was deliberately lit based on the location, timing or other circumstances, or in the absence of another feasible explanation. In light of the uncertain nature of these determinations, any assessment of the rates of deliberate firesetting must be regarded as partially speculative, and therefore an estimate only.

The report is based on vegetation fire data supplied by a large number of fire agencies across Australia. Although this report is intended to provide an overview of incidence, cause, timing and location of bushfires in Australia, in many cases the data agencies provided includes all fires that burned vegetation, irrespective of size. These are equivalent to the landscape fires documented in the Australian Government's Productivity Commission report on Emergency Management (APC 2007). The implication is that that analysis includes bushfires but also any other vegetation fire attended by fire agencies. These may be fires in suburban parkland, along roadsides, hedgefires, or fires on a football oval. There is no clear means, within many databases, for distinguishing when a vegetation fire constituted a bushfire. Hence, this report examines the propensity for deliberate firesetting in vegetation in general as opposed to bushfires specifically.

The nature of this report is technical, providing a basis for guiding research and policies adopted by fire agencies, other researchers and interested individuals. The technical nature of the report reflects the fact that in many instances the nature of the information provided by fire services is itself complex. Also there are inherent difficulties associated with attempting to source, collate and analyse multiple databases from different time periods, database structures, variable lists, etc. In order to maintain the highest level of data integrity, the data from individual agencies have been analysed separately. Although strict comparisons across agencies are typically not possible, the adoption of a common set of themes in analysis allows similarities and differences in the overall incident, timing, distribution, etc. of fires to be highlighted. However, it is not possible to entirely replicate this across agencies, as subtle differences exist in the structure of databases and the structure of fire agencies within each jurisdiction. These differences subsequently affect interpretations that can be placed on the data. This report forms the basis for a number of smaller publications that will summarise the key findings of the document.

Definitions and key concepts

This report attempts to document the number, size and distribution of potentially illegal fires lit in vegetation in Australia. It is essential, before proceeding, to understand how the two most critical terms central to this theme are defined, namely **deliberate fires** and **vegetation fires**.

Deliberate fires

Arson is the term most commonly used within our everyday vocabulary to describe fires that have been illegally lit. There are a number of underlying tenets to the common usage of this word (Willis 2004) namely:

- **the setting or starting of fire** – fire is the fundamental element of arson and without the setting of fire, arson does not exist
- **intention or wilfulness** – all definitions of arson exclude fires that are started by natural causes or accidents
- **malice** – most definitions of arson incorporate an element of malice, thereby excluding fires that are started intentionally but with positive or legitimate intent
- **property** – most definitions require that there be some kind of property or object which is burned.

Inclusion of the element of malice is problematic in many respects. Although people may light a fire illegally they do not necessarily do it with the intent to cause harm (Willis 2004).

In its strictest sense the concept of arson rests with its legal definition and there are a number of differences between the legal definition of arson and its common usage. One of the most fundamental differences pertains to the issue of intent. A number of states have adopted the model code for arson-related offences, which no longer requires that the person intended to cause harm, they only had to be reckless to causing a fire and reckless as to the spread of the fire to vegetation or property belonging to another (Model Criminal Code Officers Committee 2001:46). The most critical complication is that of using the legal definition of arson that arises only when a person is found guilty of the charge.

Using this strict legal definition poses a number of problems for establishing the number of fires that possibly were illegally lit in Australia. In many instances, there are fundamental difficulties in establishing the cause of a fire, let alone finding the perpetrator and achieving a successful prosecution in court. Analysis of data based on court convictions may provide an accurate assessment of the actual numbers of proven bushfire arson cases – according to the legal definition – but is unlikely to provide an accurate estimate of the number of unplanned, deliberate fires and potentially illegal fires across Australia each year.

In order to circumvent this issue, this report draws upon the data for all vegetation fires documented by most fire agencies from across Australia. The causes of fires recorded within these databases are documented in a number of ways, but fire agencies rarely use the term arson. The majority of urban and rural fire brigades classify fires based on the codes outlined by the Australasian Fire Authorities Council (AFAC) in the Australian Incident Reports System (AIRS). Within this system AFAC defines two separate categories of potentially unplanned deliberate or illegal fires (that is, incendiary and suspicious), with the distinction between these categories only differing in the level of proof of evidence required. Within the AIRS codes, a fire is:

- **incendiary** if there is a legal decision or physical evidence that indicates that the fire was deliberately set
- **suspicious** where the circumstances indicate the possibility that the fire has been deliberately set; for example, separate unrelated fires were found, or there were suspicious circumstances and no accidental or natural ignition source could be found.

What is a deliberate fire?

In the broad context, a deliberate fire is one where the intent of the person is to start a fire, for a person placing burning material to cause ignition (Esplin, Gill & Enright 2003). According to this definition, deliberate fires would include arson, but they would also include prescribed burns; for example, fires that were deliberately lit to achieve a set goal (such as to remove hazardous fuel, encourage germination, or to clear old growth pastures to encourage green pick) and comfort fires that are lit to keep warm and cook food. If conducted properly neither prescribed fires nor comfort fires are illegal.

In this report the term deliberate will be used to denote that a person intentionally caused an ignition where the intention was to cause, or was reckless to the possibility of causing, harm or destruction to life or property. Accordingly, this definition effectively incorporates all 'unplanned' fires (see glossary) that were intentionally started by human beings, but will include prescribed burning practices that are conducted illegally. In this report a deliberately lit fire therefore refers to illegal fire setting.

It is important to recognise that assigning a cause to a fire may be somewhat subjective. Indeed, the AIRS Instruction Manual for implementing these definitions says:

> It should be understood that this item [incendiary and suspicious fires] in particular requires the officer to make a reasonable judgment using his or her expertise and experience in the area of fire behaviour and cause. Whilst it is accepted that there will be instances where the ignition factor will not be apparent, the reporting officer should not require irrefutable evidence of the cause to be present before making a determination (AFAC, 1997; E5 Ignition Factor).

It is evident, after examining data from many different agencies, that the rates at which agencies apply the term incendiary as opposed to suspicious varies markedly both within and across agencies. For some, the number of fires classified suspicious markedly outweighs those classified incendiary, for others the reverse is the case. However, there is greater uniformity across and within agencies when the total number of fires classified incendiary and suspicious is combined into a single variable. This implies that it is likely to be the inferred certainty that varies both within and across agencies, rather than the actual instances of potentially deliberate fires. To circumvent intra- and inter-jurisdictional differences, this report adopts the term deliberate to describe all fires that were either classified incendiary or suspicious (all references to the term deliberate hereafter in this report use this definition).

This effectively says: we believe that the best guess of the attending fire officer most reasonably reflects the actual cause of the fire, and there is a reasonable probability that most suspicious fires were incendiary in origin, but that is just that physical evidence was lacking. It is implicit within this definition that there is some uncertainty in the estimated proportions of fires that potentially arose from deliberate causes, but this is the best guess it is possible to make. It is strenuously highlighted that the term deliberate used in this report is not a term typically used by fire agencies, for which this term may have different connotations.

It is also noted that not all fire agencies, particularly land management agencies, use the AIRS codes or definitions. Other agencies may use the terms deliberate, arson, malicious incendiarism, illegal burning-off, mischievousness, and motor vehicle arson. Hence in this report the definition of a deliberate fire refers to illegal fires as follows:

- **Deliberate fire**: All fires classified by fire agencies as incendiary, suspicious, deliberate, arson, malicious incendiarism, illegal burning-off, mischievous.

Vegetation fires

Many different terms are used to describe fires that occur in vegetation, often with subtly different emphasis and meaning. The term bushfire is a uniquely Australian term that is used to describe an unplanned fire that occurs in the 'bushland', incorporating fires that occur in grass, (grassfires), forest (forest fires), scrub (vegetation composed of shrubs; scrub fire) and other vegetation categories; that is, any fire that occurs outside the urban environment (Ellis, Kanowski & Whelan 2004). This is similar to the term wildfire or sometimes wildland fires used in the United States.

The Australian Forestry and Forest Products Division of the CSIRO (2000) defines as wildfires all vegetation fires that were accidentally lit, lit by arson or the result of a lightning strike, and that burn unchecked. They distinguish wildfires from fires that were deliberately lit to achieve a set goal, such as to remove hazardous fuel, encourage germination, or to clear old growth pastures to encourage green pick, which are collectively called 'prescribed' or 'controlled' fires.

The common usage of the term bushfire, by people outside of fire and nature-based agencies, tends to be shaped by those events that most commonly appear in the media; that is, large, dangerous and devastating fires that sweep through bushland, typically destroying everything in their path.

Use of the term wildfire in most fire agencies' databases, the definition that ultimately governs the types of fire incidents available for analysis, is somewhat different from those outlined above. The majority of urban and regional/rural-based agencies (that is non-land management agencies) classify fires based on the AIRS codes. Within this definition a wildfire specifically encompass all fires where the type of incident code is from 160 to 179 (Table 3 in the Methodology section). Effectively this encompasses all fire incidents the fire agency attends that occur in vegetation irrespective of size, incorporating both small (less than 1 ha) and large (greater than 1 ha) fires. Hence, in an urban area a 'wildfire' may include a fire that genuinely occurs in an area of native vegetation, as an isolated pocket within a suburb, or along the urban interface, but equally may include fires that occur in grass along the roadside (such as where a single tree or shrub is set on fire), on the local oval, or in shrubs outside the local hospital, residence, restaurant or police station. The latter fires are not what one typically calls a bushfire or a wildfire.

Ascertaining which of the fires attended by fire agencies genuinely constituted a bushfire according to the CSIRO definition is not a simple task. The dominant types of fires each agency attended will be shaped by their responsibilities and jurisdiction. For example, it is probably reasonable to assume that a higher proportion of fires land management agencies attended were genuinely bushfires, in the classical sense. Similarly, rural-based agencies might attend a higher proportion of fires that pertain to rural practices; for example, fires started on farmland as a result of harvesting or slashing, or fires that result from the escape of burn offs (prescribed burning). It cannot be assumed, however, that all fires these agencies attend fall within these broad categories. A number of factors that vary between the states and territories will determine which agency will attend, for example:

- The jurisdictions of individual agencies commonly encompass a broad range of environments. For example, although the jurisdiction of urban brigades may largely encompass urban areas, they also typically include expanses of open space, pockets of remnant vegetation, an urban–rural/forest interface. Similarly, the jurisdiction of many rural/regional brigades includes both rural and urban areas. In some instances, urban areas occur adjacent to or, as is the case for the Royal National Park in New South Wales, within areas that come under the jurisdiction of land management agencies.

- In order to meet their responsibilities to protect people and the environment, individual agencies commonly attend fires on lands that directly lie outside their tenure or jurisdiction.
- There is typically a high level of cooperation between fire fighting agencies, with individual agencies volunteering services for fires that lie outside their jurisdiction. These fires may be local, in another region or even in another state or territory.
- The dominant type of fires agencies attend is dependent on the structure of the agencies, and the distribution of responsibilities for fire services within a given state or territory, as well as the distribution of people and the dominant land uses that occur within each area. All can vary marked within and between each state and territory.

Unfortunately, the 'Type of Incident' variable was not available for many databases, so small versus large vegetation codes cannot be used as a determinant. Moreover, although many small vegetation fires that occur in urban areas may not constitute a bushfire in the classical sense, size is not by itself necessarily a determinant. Without precise grid coordinates it is not possible to determine the exact environment in which each fire occurred. Even if this information were available, it is beyond the resources of this project to undertake such an analysis.

This report uses the term vegetation fire to describe all fires attended by fire agencies that occur in vegetation. These are distinguished from those that occur in buildings (structural fires) and fires that occur in vehicles (vehicle fires). The term bushfire is retained for specific instances where it has been confidently identified as a vegetation fire that has burned unchecked. This includes historically large bushfires.

The majority of vegetation fires that fire agencies attended are unplanned. However, databases from land management agencies may incorporate a small number of fires recorded as prescribed burns. In most instances fires arising from fire management practices are not documented in the same database as unplanned fires, unless the fire escaped control lines, in which case it no longer represents a controlled fire.

Key themes

This report incorporates five key themes that wherever possible are replicated across analyses for individual agencies and jurisdictions; the themes address underlying questions about the nature of bushfires in general, and bushfire arson in particular in Australia. These questions include:

- What are the most common causes of bushfires in Australia? This theme examines the overall incidence of bushfire, the potential role of arson relative to other fires causes, and specific causal information – ignition factors, form of heat of ignitions, people identified as being responsible, for example, fires started by children, and specific types of fires, for example, smoking related fires.
- How do the frequency and causes of fires vary spatially, at both regional and local scales, by the type of complex/land use, and in relation to population distributions within that jurisdiction?
- How do the frequency and causes of fires vary temporally – by season, week of year, day of week, time of day, and in relation to adverse climatic conditions?
- What is the size of the area burnt by fires? That is, the size distribution by fires of different causes, variables impacting on the total area burnt, total area burnt by deliberate and non-deliberate fires, particularly as it pertains to adverse bushfire seasons.
- What is the relationship between bushfire arson and periods of adverse bushfire weather? This portion of the analysis draws on information about status of fire restrictions and total fire bans, bushfire danger ratings, available weather information (rare) and firesetting activities during particularly adverse bushfire danger periods.

In addition, the analysis locally examined the type of vegetation burned and the incident type to enable the reader to more accurately assess the type of fires that individual agencies attended. In one specific instance, for the Western Australian Department of Environment and Conservation, the analysis examines specific environmental factors, to highlight the impact that arson potentially has on ecologically vulnerable and endangered ecosystems.

Sources of data

Individual state and territory governments are responsible for delivering emergency services, including the arrangements for protecting life, property and the environment. Most jurisdictions divide responsibilities for delivery of fire services between several agencies based on the discrete function of the organisation and the geographical area, although the structure and responsibilities of individual agencies varies across jurisdictions. The major agencies responsible for suppressing wildfires in Australia are summarised in Table 1.

The vegetation fire data of individual agencies were examined over several consecutive years (typically a five-year period), to take account of the natural fluctuations in the incidence of bushfire that arise from climatic variability. For the list of agencies from which data was acquired, the interval over which the data pertained, and additional comments about the data see Table 2 in the Methodology section.

<table>
<tr><th colspan="4">Table 1: Agencies responsible for suppressing wildfires in Australia[a]</th></tr>
<tr><th rowspan="2">Jurisdiction</th><th>Urban</th><th>Rural</th><th>Land management agency</th></tr>
<tr><th>Principally attend fire incidents within major urban centres</th><th>Principally attend fire incidents in rural areas</th><th>Attend fire incidents in National Parks and state forests</th></tr>
<tr><td rowspan="2">New South Wales</td><td>NSW Fire Brigades provides urban fire services to major metropolitan and regional urban centres; principally permanent and retained firefighters working from fire stations but also includes community fire units and their members</td><td>NSW Rural Fire Service provides fire services to most of regional New South Wales outside major urban centres, but does provide firefighting services in more than 1,200 towns and villages; fire-fighting duties principally lie with volunteers</td><td>Forests NSW is responsible for managing public native forests as well as hardwood and softwood planted forests</td></tr>
<tr><td colspan="2"></td><td>National Parks and Wildlife Service is responsible for managing National Parks and other conservation reserves</td></tr>
<tr><td rowspan="2">Victoria</td><td>Metropolitan Fire and Emergency Services Board provides urban fire services coverage from the Melbourne CBD to the middle and outer suburbs; principally permanent and retained firefighters working from fire stations</td><td></td><td>Department of Sustainability and Environment is responsible for public lands</td></tr>
<tr><td colspan="2">Country Fire Authority provides urban and rural fire services coverage for all parts of Victoria other than the Melbourne Metropolitan Fire District and public lands; this includes outer metropolitan Melbourne and regional centres; incorporates some career firefighters who work from urban stations but is heavily reliant on volunteers in regional Victoria</td><td></td></tr>
</table>

Table 1: Agencies responsible for suppressing wildfires in Australia[a] (continued)

Jurisdiction	Urban Principally attend fire incidents within major urban centres	Rural Principally attend fire incidents in rural areas	Land management agency Attend fire incidents in National Parks and state forests
Queensland	Queensland Fire and Rescue Service incorporates both urban and rural fire services (Queensland Rural Fire Service); is staffed by largely permanent and volunteer staff		Queensland Parks and Wildlife Service is responsible for managing parks and forests reserves
			Forestry Plantations Queensland is responsible for managing softwood and hardwood forest plantations from the former Department of Primary Industry – Forestry
			Department of Natural Resources and Water (Forest Products) subsequent to the South East Queensland Regional Forests Agreement (December 1999); is responsible for native forests set aside for logging
South Australia	Metropolitan Fire Service provides fire services to major urban centres in South Australia; permanent and retained firefighters working from fire stations		Department of Environment and Heritage is responsible for fires that are on, or threaten, national parks and other conservation areas in South Australia
	Country Fire Service – provides fire services in rural areas as well as in smaller urban centres in South Australia; draws on volunteer firefighters		Forests SA manages state-owned forest resources
Western Australia	Fire and Emergency Services Authority (FESA) provides and coordinates fire services across WA. The Operations Services division within FESA incorporates two components – the Fire and Rescue Service of Western Australia (career and volunteer) and bushfire brigades (volunteer). Career firefighters within the Fire and Rescue Service operate from stations in metropolitan Perth and some major regional centres. The remainder of the state outside national parks and forests is covered by the Volunteer Fire and Rescue Service and volunteer Emergency Service Units (ESU), which are an amalgamation of the FRS, Bush Fire Service (BFS) and State Emergency Service (SES)		Department of Environment and Conservation is responsible for fires that are on, or threaten, national parks and forests in WA
Tasmania	Tasmania Fire Service provides coverage for both urban and rural areas, excluding national parks and state forests; comprises both career and volunteer firefighters		Tasmania Parks and Wildlife Service is responsible for managing national parks and other conservation reserves
			Forestry Tasmania is responsible for managing the state forests
Northern Territory	NT Fire and Rescue Service comprises both urban stations and volunteer/community fire units; includes permanent staff, part-time auxiliaries and volunteers; principally operates in urban/community settlements	Bushfires Council responds only to grass fires and bushfires on land outside the Fire and Rescue Service response areas	
Australian Capital Territory	ACT Fire Brigade principally provides fire services in urban areas; comprises career firefighters	ACT Rural Fire Service is principally responsible for suppressing bush and grass fires within rural and remote areas of the ACT; incorporates one brigade staffed by ACT land management agencies	

a: excludes brigades employed by large-scale public and private land managers; port, mining and other infrastructure brigades; and land management departments and brigades operating under Australian Government jurisdiction (for example, airport and defence installations)

Limitations to accuracy of fire information

There are fundamental limitations to the accuracy of fire information presented in this report. These derive from inherent limitations associated with the detection and investigation of fires, as well as inaccuracies that arise from the documentation of those events.

Inherent limitations

Two factors where there are inherent limitations to the accuracy of the data relate to the cause of a fire and the time a fire occurred.

Causal determination: There are inherent uncertainties in the labelled cause of a fire. Determining the cause of a fire requires a high level of skill and knowledge. Specialist fire investigators take into account the available physical and circumstantial evidence, such as burn patterns, signs of the fire's path, weather conditions and the presence of human activity as well as potential factors that influence fire behaviour in outdoor environments. However, such investigations are resource intensive, requiring many hours of investigation by highly skilled investigators, and hence only a small proportion of all vegetation fires attended by fire agencies are subject to such investigations. The resources available for, or access to, such resources are likely variable across the different agencies. Moreover, the presence of a trained fire investigator does not necessarily guarantee that the cause of a fire will be established with absolute certainty, due to a lack of physical evidence.

Individual fire agencies typically maintain two distinct databases, one – the incidents database – documents all fire incidents the agency attended; the other – the investigations database – records detailed information about cause investigations. There are advantages and disadvantages to analysing data from these distinct data sources. Detailed investigations are likely to provide a greater accuracy regarding the cause and origin of a bushfire. However, although the cause of those fires may be known with a greater degree of accuracy, the subset of bushfires investigated is not necessarily representative of all bushfires; fires are only referred to investigation teams in specific instances and generally comprise a small proportion of all bushfires attended by fire agencies. Conversely, the incident data may provide a more accurate guide to total incidence of bushfire, but there is likely to be greater uncertainty as to the cause of the fire. There is likely to be a greater level of subjectivity in the assessment, with the accuracy of the assessment being subject to the experience of the officer.

This report is based entirely on the incidents data, which means that causes of these fires have been subjectively determined.

Time fires occurred: There are inherent difficulties in specifically pinpointing the time a fire occurred. The time documented may variably be recorded as the detection time or the alarm time. Technically, these do not necessarily equate to the same time, although in most instances the delays between the time a fire is detected, the time it is reported, and the time the fire station is notified are likely small, and of little consequence. However, such delays make identification of unique fire instances in large databases problematic.

The greatest uncertainty about the time of ignition relates to the time that transpired before the fire was detected, and the alarm was raised. In urban environments this is likely comparatively small, although may be affected by the time of day the fire occurred. However, in remote and rural areas fires may not be detected for hours or days depending on the remoteness, degree of through traffic and observable evidence of fire.

Limitations of databases

The accuracy of the analysis was ultimately affected by the quality and structure of information available for analysis. Inherent limitations in the data and database structure, as well as the methods adopted in the analysis affected the accuracy of information provided in this report. These limitations manifest in several different ways, namely data quality, lack of uniformity in database structure, complexity in fire incidence data, presentation of spatial information, and unique instances.

Data quality: The accuracy of data recorded in the database appears highly variable both between and within individual agencies. This is most evident for spatial and temporal information. As an example this may be reflected in postcodes that do not exist, grid references that plot in the middle of the ocean, not valid times. An additional problem relates to inclusion of information that can only to be understood by local people. Given that such errors exist within the spatial and temporal information, it follows that there are probably errors within the causal data and other data fields. With one or two exceptions (see Methodology), the data, particularly as it pertains to the causal field, has been taken at face value and not altered.

Lack of uniformity in database structure: One of the greatest hurdles in undertaking a multiple agency analysis pertains to lack of uniformity within the database structure available for analysis. Fire agencies nationally are increasingly trying to introduce a consistent method and structure for recording fires. Most non-land management fire agencies use the classification scheme outlined in the Australasian Incidence Reporting System (AIRS). Although fire agencies are working towards generating a core set of data that are uniform across agencies, these were not necessarily reflected in the datasets available for analysis because:

- The AIRS was only introduced in 1997 and adoption of this system did not occur simultaneously or uniformly.
- Reporting within the AIRS system occurred, in some instances, over several years; and in some cases older data were retrospectively incorporated into the AIRS database structure.
- The types of variables available for analysis were not consistent across agencies even though agencies used a similar database structure.
- Agencies may record a number of variables, but not all variables were supplied with the dataset made available for analysis.
- Most land management agencies do not use either AIRS , as these database systems are not necessarily compatible with the types of information such agencies are interested in storing. This requires agencies to either maintain two distinct databases or undertake substantial development of the database. Given the comparatively small number of fires, it may be beyond the capacity of many land management agencies to do either.
- The time periods of fires available for analysis differed between agencies and across jurisdictions and therefore prevented a direct comparison between agencies.

Database structures are continually evolving, and the information used in this report does not necessarily accurately reflect the current situation practiced in individual agencies.

Complexity in fire incidence data: Fire reports typically encapsulate a complex array of information, about the fire scene and if possible, when, where, how and why the fire occurred. It is inherently difficult to capture all details of a fire in a database structure without it becoming excessively unwieldy. Many fires result from multiple factors, and database structure are generally ill equipped to deal with multiple parallel options. Additional complications arise, because there are varying levels of uncertainty associated with any one field. The AIRS codes that fire agencies use attempt to capture as much information as possible. Although this provides a powerful way of documenting detailed fire information, there is inherent flexibility within the database that potentially enables the same type of event to be coded in multiple ways.

The complexity of the database and the potential for different means of coding necessarily affects the level to which the information extracted from the database accurately reflects the fire event. Further inaccuracies may be introduced when one attempts to reduce this information into a simple causal classification scheme, as adopted in this study, as this will rarely encapsulate this complexity, without introducing ambiguous classifications.

Presentation of spatial information: It is useful when analysing large databases to group information so it can be more easily understood. This is true of spatial information.

In this report, the spatial distribution of fires is examined on several levels, at both regional level, and more localised levels. The principle structure for regions adopted in this analysis was loosely based on Australian Bureau of Statistics tourism regions (2005). The principal reason for adopting this structure relates to the fact that this type of statistical area is one with which most people are conceptually familiar. At a more localised level, the data may be analysed at using smaller ABS statistical areas or even a postcode or suburb level. The type of unit used and the way locations were assigned to specific regions varied between datasets, depending on the type of information available, the purpose of the analysis, and the type of information that individual agencies regarded as appropriate.

There are several important things to note about the spatial analysis of fires, namely:

- There are fundamental differences between the statistical regions, divisions, subdivisions, local areas used in this report and those defined by the Australian Bureau of Statistics. In this report, fires were assigned to a statistical location based on the suburb name or postcode. However, there is not a direct correspondence between a suburb and postcode and statistical areas. The latter often crosscut suburb and postcode boundaries.
- It is inherently difficult to classify fires attended by land management agencies into any systematic regional structure, as owing to their large size, they tend to crosscut, statistical areas and regions. Hence, in the analysis of data from land management agencies this analysis has tended to assign reserves to a particular region based on the region name or to adopt the regional structure provided by individual agencies. This necessarily means there is not a direct correlation between the regional structures for agencies within the same jurisdiction, despite the fact that they possess similar names.
- Although information may be presented at a regional or local level, caution is required before using this information to shape policy or procedures for arson reduction strategies. Patterns that manifest at a broader level are ultimately an amalgamation of many patterns that manifest at smaller levels, and it is necessary to investigate the specific causes of high numbers of fires within a local area before implementing arson reduction strategies, if those strategies are to prove successful. Vegetation fires have many different causes. Moreover, there are commonly many different reasons underlying higher incidents of deliberate fires, including different demographic structures or social issues. Hence, the trends presented in this report cannot be assumed to be representative at a local level, but rather provide a broad guide to the trends observed nationally and within individual jurisdictions and regions.

Unique instances: Individual bushfires analysed in this report do not necessarily represent a unique fire instance. More than one fire agency may attend the same incident if the fire is located next to a jurisdictional boundary. For example, land management agencies are responsible for managing all lands under their control (be they economical or ecological in nature). Hence, they may attend fires outside their jurisdiction, alongside urban or rural brigades in order to prevent that fire spreading into their tenure. The reverse is also the case. During large bushfire campaigns, resources are, to some extent, pooled in order to protect life and property. Hence, agencies are called upon or volunteer services to areas that lie outside their jurisdiction, be that within or external to a particular state or territory.

As individual agencies record deployment of resources to individual fires, those instances are duplicated across agencies. Such instances are unlikely to markedly affect the total fire frequencies calculated from the accumulated data, but may grossly affect calculations based on total area burned, as attendance by multiple agencies is most likely for large fires, and large fires constitute the bulk of the total area burned. It is impossible to identify or remove all such instances, and no attempt has been made to do so, as not all agencies will document the same detection time or data, point of origin or even area burned in these fire instances. During large bushfire campaigns, when conflagrations result from the merging of many different fires with multiple points of origin and potential causes, there are potentially many different ways of documenting these fires.

It is also possible that some fires may be duplicated internally within some agencies. This may occur in instances where more than one brigade attended a particular fire. However, different agencies have different ways of documenting attendance of multiple brigades at a fire event. Whether this practice occurred and the proportion of instances where this may occur has not been evaluated. This means that a single fire may be represented more than once in the databases and therefore in the analyses in this report.

Implications for the data presented in this report

Information about causal attributions is a 'best guess' and therefore the trends presented in this report are an approximation. It would be misleading and counterproductive to integrate the analyses for all agencies for each state or territory jurisdiction because each had different database structures and covered different timeframes; as well, duplication of large fires across agencies would affect analyses of the total area burned. Data from each agency are therefore presented independently, making use of similar underlying variables. In specific instances, a joint or side-by-side analysis has been undertaken to draw attention to the commonalities or to highlight differences.

Although attempts have been made to standardise the way in which fires are classified, this was not entirely possible. The onus is on the reader to familiarise themselves with the methodology used in individual instances (see Methodology); instances where this affects data interpretation are typically highlighted in the text.

It is important to take these points into consideration when interpreting the data.

Sources of background information

AFAC 1997. *Australasian Incident Reporting System instruction manual*. Australian Fire Authorities Council. Mount Waverley, Victoria.

APC 2007. *Report on government services 2007, Part D: emergency management*. http://www.pc.gov.au/gsp/reports/rogs/2007/emergencymanagement/index.html

Esplin B, Gill AM & Enright N 2003. *Report of the Inquiry into the 2002–2003 Victorian Bushfires*. Melbourne: State Government of Victoria

Willis M 2004. *Bushfire arson: a review of the literature*. Research and public policy series no. 61. Canberra: Australian Institute of Criminology. http://www.aic.gov.au/publications/rpp/61

Methodology

Sample set used

The number of agencies who have responsibility for attendance at, and suppression of fires, and the relationships between those agencies varies between state and territory jurisdictions, as outlined in Table 1. Data for vegetation fire incidents were sourced from 18 fire agencies, with representatives from each state and territory. The databases provided refer only to those fires recorded within the incidence database: they do not include information recorded in the separate fire investigations databases that may be maintained by individual agencies. Although the incidence data cover the overwhelming majority of vegetation fires in Australia, there were some omissions (Table 2).

Database structure and period of data analysed

The majority of urban and rural services use the Australasian Fire Authorities Council's (AFAC) Australian Incident Reporting System (AIRS) to classify information about individual incidents including the location, timing, origin, form of heat of ignition, ignition factors etc of individual fire incidents. This database contains information about all incident types attended by individual agencies, from structural, vehicle, and vegetation fires through to hazardous chemical spillages, rescue and emergency medical service incidents, among other incident types. While most agencies currently use AIRS, at the time the analysis was undertaken, there were a number of inconsistencies across those databases that prevented integration of the fire data into a single database. These inconsistencies arise from several factors, as summarised below.

- The AIRS (I) database structure was only implemented in 1997. The time at which individual agencies implemented the system varied. For some, the system was fully operational from 1997 onwards, while for others, the implementation occurred at some later point or the system was implemented progressively over a number of years.
- In some instances the implementation of the AIRS database structure occurred midway during the period analysed and the data supplied were an amalgamation of data from two different database structures; either a physical combination of the two datasets – maintaining the classification systems used in each – or by retrospectively incorporating existing data into the AIRS database. The discordance between database structures affected the period available for analysis and/or the interpretation that could be made from the data.
- Data for agencies utilising the AIRS database structure were sourced via different pathways. Some AIRS databases were sourced from AFAC, while others were sourced from individual agencies (see Table 2). At the time of making data requests, not all agencies had submitted data into the centrally-held AFAC AIRS database or the data held within that database at the time were of inferior quality and so data were independently sourced from individual agencies.
- Many land management agencies do not report fire data within the AIRS database structure. To some extent the current structure of the AIRS database is incompatible with types of fire data recorded by land management agencies. Contribution to AIRS would require the maintenance of two independent databases.

The result is that the variables available for analysis, the timeframe for which data were available, and the way in which the data were structured or categorised varied across databases. These differences prevented agencies and jurisdiction using a single internally consistent database structure. Hence data from individual agencies within each jurisdiction were analysed and presented separately.

While this approach created a large report, it has the advantage that trends pertinent to individual agencies are not dominated by data from agencies or jurisdictions that record markedly higher numbers of fires. This approach has also highlighted fundamental deficiencies in the data, thereby providing a basis for future improvements.

Comparisons across agencies and jurisdictions are facilitated by the adoption of a simplified causal field, by analysing similar types of information in different databases and by drawing on specific common variables. Nevertheless, it was not possible to completely remove all inconsistencies, and it is essential that the reader be aware of the methodology that underlies the analysis and the implications that this has for the interpretation of the data. Many of these inconsistencies are highlighted in the text where they are relevant. Some relevant similarities and differences between datasets and the classification of data are summarised in Table 4 and are discussed in further detail below.

Vegetation fires

As outlined in the introductory section, this analysis examined the incidence of vegetation fires generally as opposed to bushfires specifically. This reflects the fact that there are fundamental limitations within the databases themselves that often prevent such a distinction being made, the inherent difficulty of actually defining what constitutes a bushfire using quantitative and reproducible techniques, and philosophical arguments about the potentiality of an action; the actual reality (for example 1 ha burned on the road verge) does not necessarily reflect potential consequences of an action (that the fire could have easily spread in to the neighbouring national parks and burned 10,000 ha). The latter relates to the philosophical question that underpins attitudes toward bushfire arson. Even if we could distinguish between what may or may not have constituted a bushfire in the database, is it valid to distinguish between acts of arson just because one fire burned 1 ha but another burned 10,000 ha? The balance between small and large fires will vary substantially between agencies, depending on jurisdiction and responsibilities. For example, urban brigades are likely to attend a higher proportion of small fires than a land management agency whose jurisdiction covers national parks or state forests. The methods used to identify and classify vegetation fires used in this analysis are outlined below. The method used varied depending on whether the agency recorded information using AIRS codes, and the structure of information provided. Whether or not individual agencies used AIRS cases and specific information regarding the structure of that data are outlined in Table 4.

AIRS databases: wildfires

All urban and most rural fire agencies record fire incidents using AIRS (Table 4). Although individual agencies may have attended a variety of incident types (particularly urban-based agencies), in most cases the data supplied by the agency included only vegetation fire data. Where data were supplied by AFAC (see Table 4), it was necessary to distinguish wildfires from other fire incident types.

For agencies utilising the AIRS database structure, the analysis was conducted on all fires defined as a wildfires – that is, all fires where the type of incident variable code (A23) was recorded as 160 to 179 (Table 3). Nevertheless, some modifications occurred in both the FESA and SAMFS analyses as illustrated below.

FESA

FESA data between 1997–98 and 2001–02 derive from two distinct encoding formats. The 2000–01 and 2001–02 data were coded using AIRS, whereas the 1997–98 and 1998–99 data appeared to have been coded using an alternative scheme that was subsequently incorporated into the AIRS database. The transfer between these two systems occurred during the 1999–2000 season. Divergence in the format prevented a consistent interpretation of causal data over the five-year period.

The FESA analysis used 1997–98 and 2001–02 (denoted AFAC–FESA in the text) relied on using two subsets of data. In all cases including causal information (for example, non-deliberate or deliberate, causal category, heat of ignition etc), which was most cases, the analysis only examined fires from 2000–01 and 2001–02. However, some analyses of temporal trends used the five years of data as this yielded greater accuracy.

Where only the 2000–01 and 2001–02 data were used, vegetation fires were defined using the AIRS wildfire definition; that is, all instances where Type of Incident (A23) = 160 to 179. All analyses based on the 2000–01 to 2001–02 data are consistent with other AIRS databases (with the exception of the SAMFS). Owing to changes in database codes this definition could not be used for the 1997–98 and 2001–02 data, failing to identify vegetation fires from 1997–98, 1998–99 and part of 1999–2000. The analysis of the five-year data is based on an alternative definition of vegetation fires. In this instance a vegetation fire is all instances where the vegetation variable was recorded as 0 to 99.

There is not an exact correspondence between the AIRS wildfire category used for the 2000–01 and 2001–02 subset and the alternative wildfire classification devised for the 1997–98 to 2001–02 interval. However, there is a broad overlap. Of the 21,990 fires recorded for the 2000–01 and 2001–02 seasons, 13,769 cases overlapped. There were 177 cases where fires were classified as wildfires based on the ‘type of incident’, but were not recognised using the alternative wildfire definition and 10 cases where fires were classified as bushfire using the alternative wildfire definition but not considered wildfires based on the ‘type of incident’.

The FESA analysis also draws on summary fire data sourced independently from FESA for the 2000–01 to 2006–07 interval. All fires within this dataset qualify as wildfires according to the AIRS definition.

South Australia Metropolitan Fire Service (SAMFS)

Although in an AIRS format, the analysis of SAMFS data differed from that used elsewhere in several fundamental ways:

- The data, particularly prior to 2001–02, were compromised by ongoing industrial action. Intervals affected by industrial action included:
  - 1997–98: 15–26 September 1997 and 24 February – 20 March 1998
  - 1998–99: 15 December 1998 – 28 April 1999 and 12–28 May 1999
  - 1999–2000: 25 January – 30 June 2000
  - 2000–01: 1–2 July 2000 and 21–22 February 2001

Variations in both the length and timing of the industrial disputes varied, and total fire numbers cannot be used to evaluate genuine temporal variations in bushfire numbers, except for the interval from 1997–98 to 2000–01.

The SAMFS analysis is only based on vegetation fires where the ‘activity in the area’ was designated ‘malicious activity’ (AIRS code 81), as this was the only data supplied. Consequently, it is impossible to accurately ascertain the significance of deliberate fires relative to other causes. Some broad estimates are made within the text using the combined ‘grass’ and wildfire data provided by the SAMFS in their annual report (available online at http://www.samfs.sa.gov.au/) using the data supplied for rubbish and grass fires associated with malicious activity. Using this combined information it is estimated that 17 to 31 percent of all vegetation and rubbish fires attended by the SAMFS were recorded as having ‘malicious activity in the area’ in the interval from 1997–98 to 2005–06. For the seasons not impacted by industrial action (2002–03 to 2005–06) the value was 17 to 20 percent. It is emphasized that this information is only an estimate and therefore potentially subject to error.

Non-AIRS databases

In most instances the data supplied by individual agencies that, at the time of making the data requests were not using AIRS, only included vegetation fires. All land management agencies fell within this category. However, in some cases, individual land management agencies included a small number of fires that were variously categorized as rubbish tip, rubbish fires, waste disposal etc. These may have genuinely been burning rubbish or alternatively a vegetation fire that resulted from the escape of a rubbish fire at a rubbish tip, an incinerator in the backyard etc. – the available information is unclear. Given the lack of any corroborating evidence these ‘rubbish fires’ were included within the vegetation fire analysis conducted in this report, with the number of cases involving rubbish fires being documented in Table 4. In fact, all cases were used for agencies not using the AIRS database structure with the following exceptions:

Forestry Plantations Queensland: Analysis was based on fire instances with a unique ‘fire id.’ and ‘fire no.’, thereby removing duplicates that existed within the database.

Queensland Parks and Wildlife Service: The variable ‘report id’ identified unique bushfire instances in the QDPWS database. These were 86 cases of duplicated records that were removed prior to analysis.

South Australia Country Fire Service: SACFS fires were classified into three types of fires using the ‘fire type’ variable provided:

- *vegetation fire*: forest fires, grass or stubble fire, scrub and grass fire, tree fire
- *rural fire*: grain/crop fire, haystack
- *rubbish fire*: dump, rubbish bin, rubbish fire.

The SACFS analysis was restricted to those fires that fell within the vegetation fire category above.

South Australia Department of Environment and Heritage: In the dataset supplied, the variable ‘fire number’ did not discreetly identify fires. In numerous cases, the fire number was repeated and in some cases identified fires with the same cause and on the same date. This mainly occurred when the cause was lightning, suggesting that these duplications may indicate multiple lightning strikes. In some cases, fire number also identified multiple other fires that may have occurred on different dates and with different causes. For analysis purposes, it was considered that each entry in this dataset was a separate fire, although it is acknowledged that the recording of multiple lightning strikes as separate fires may tend to increase the proportion of fires assigned to natural causes, as compared to other datasets where this did not occur.

Table 2: Agencies providing data to this study		
Agency	**Date range**	**Comment**
NSW Fire Brigades	1997–98 to 2001–02	
NSW Rural Fire Service	1999–2000 to 2003–04	
NSW National Parks and Wildlife Service	1995–96 to 2003–04	
Forests NSW	1997–98 to 1/12/2003	
Metropolitan Fire and Emergency Services Board	1997–98 to 2001–02	
Victorian Country Fire Authority	1999–2000 to 2003–04	
Victoria Department of Sustainability and Environment	1993–94 to 2003–04 (some older data used)	
Qld Fire and Rescue Service	1997–98 to 2001–02	Data does not provide coverage of fires attended by the Rural Fire Services in regional Queensland, as reporting of fires by volunteers in that jurisdiction is voluntary. The Rural Fire Service provides fire services for 93 percent of the total area of the state, outside of major urban centres
Qld Parks and Wildlife Service	1999–2000 to 2003–04	Data is incomplete but strongly impacted by numerous and substantial tenure changes since the South East Forest Agreement (changes commencing 1999–2000)
Forestry Plantations Queensland	1975–76 to October 2004	Data subsequent to 1999–2000 subject to changes in land tenure (as above)
Qld Department of Natural Resources and Water (Forest Products)	No data	
SA Metropolitan Fire Service	1997–98 to 2005–06 (1998–99 to 2000–01 variably incomplete due to industrial action)	Data only includes a subset of wildfires (fires where the activity in the area was reported as malicious); analysis draws on both rubbish and vegetation fires
SA Country Fire Service	1997–98 to 2003–04	
SA Department of Environment and Heritage	1975–76 to 2003–04 (two databases combined)	
Forests SA	No data	
WA – Fire and Emergency Services Authority	1997–98 to 2001–02 (but principally 2000–01 and 2001–02)	This dataset is incomplete: most complete coverage appears to be provided for metropolitan Perth and major regional centres
WA – Department of Environment and Conservation	1999–2000 to 2002–03	
Tasmanian Fire Service	July 1999 – November 2004	
Forestry Tasmania	No data	
Tas. Parks and Wildlife Service conservation reserves	No data	
NT Fire and Rescue Service	1999–2000 to 2003–04	
NT Bushfires Council	No data	
ACT Fire Brigade	No data	
ACT Rural Fire Service	1975–76 to 2002–03 Part data (see comments)	Analysis conducted on a small subset of the wildfires acquired from ACT Parks Conservation and Lands (Environment ACT); included data initially derived from the Bushfire Council (ACT Rural Fires Service), as well as from Canberra Urban Parks and ACT Parks and Conservation (both now within Environment ACT); dataset represents only a subset of fires attended by ACT Rural Fire Service

Table 3: Type of incident codes for vegetation fires in the Australasian Incident Reporting System

AIRS code	Type of incident (A23): Wildfire
161	Forest or wood fire (more than 1 ha)
162	Scrub or bush and grass mixture fire
163	Grass fire
164	Cultivated grain or crop fire
165	Cultivated orchard or vineyard fire
166	Cultivated trees or nursery stock fire
169	Vegetation or other outside fire not classified above
160	Vegetation or other outside fire; insufficient information to classify further
171	Small vegetation fire less than one hectare
179	Small vegetation fire not classified above
170	Small vegetation fire; insufficient information to classify further

Table 4: Summary of databases and variables used in analysis – part one

		Period	AIRS codes	Data provided by	Vegetation fire definition	AIRS-Form of heat of ignition	Cause based on variable	Child; child's age
NSW	NSWFB	1997–98 to 2001–02	Yes	AFAC	AIRS wildfire	Yes	Ignition factor	Yes, Yes
	NSWRFS	1999–00 to 2003–04	Yes	NSW RFS	AIRS wildfire	No	Ignition factor	Yes, Yes
	NSW NPWS	1995–96 to 2003–04	No	NSW NPWS	Vegetation fires (includes 5 fires at rubbish tips)		Cause	No
	SFNSW	1997–98 to 1–12–2003	No	SFNSW	Vegetation fires (includes 12 fires relating to rubbish disposal)		Cause	No
Vic	MFB	1997–98 to 2001–02	Yes	AFAC	AIRS wildfire	Yes	Ignition factor	Yes, Yes
	CFA	1999–00 to 2003–04	Yes	CFA	AIRS wildfire	No	Ignition factor	Yes, Yes
	DSE	1993–94 to 2003–04[a]	No	DSE	Vegetation fires (includes 85 domestic rubbish fires; 31 industrial rubbish fires)		Cause	Yes, No
Qld	QFRS	1997–98 to 2001–02	Yes	AFAC	AIRS wildfire	Yes	Ignition factor	Yes, Yes
	FPQ	1975–76 to October 2004	No	FPQ	Vegetation fires (unique records only)		Cause	No
	QPWS	1999–2000 to 2003–04	No	Qld PWS	Only wildfires (unique records only)	No	Cause	No
SA	SAMFS	1997–98 to 2005–06[b]	Yes	SAMFS	AIRS wildfire (only fires where activity in the area was categorised as malicious)	Yes	Activity in the area='Malicious'	Yes, Yes (incomplete)
	SACFS	1997–98 to 2003–04	Yes & No[e]	SACFS	Vegetation fires	No	Additional factor & Fire cause	No
	SADEH	1975–76 to 2003–04[c]	No	SADEH	Vegetation fires	No	Cause; comment	No
WA	FESA	1997–98 to 2001–02[d]	Yes	AFAC	AIRS wildfire	Yes	Ignition factor	Yes, Yes
	WADEC	1999–2000 to 2002–03	No	DEC	Vegetation fires		Fire cause description	No
Tas	TFS	July 1999 to November 2004	Yes	TFS	AIRS wildfire	No	Ignition factor	Yes, Yes
NT	NTFRS	1999–00 to 2003–04	Yes	NTFRS	AIRS wildfire	Yes	Ignition factor	Yes, Yes
ACT	ACT PCL	1975–76 to 2002–03	No	ACT PCL	Vegetation fires; does not include urban data	No	Ignition factor (not AIRS)	No

Table 4: Summary of databases and variables used in analysis – part two

		Smoking related fires defined using variable	Smoking related fires; cause	Classification of natural fires	Date variable	Time: (Y/N); variable
NSW	NSWFB	Form of heat of ignition division = 'Heat from smokers' materials'	82% accidental; 6% incendiary; 7% suspicious; 4% unknown	30.1% lightning; 27.3% high wind; 41.5% natural condition event NC/IO[i]; 0.9% high water	Alarm datetime	Yes; alarm datetime
	NSWRFS	Ignition Factor = 'Abandoned, discarded material' (Code 310)	100% accidental	73.8% lightning; 18.2% high wind; 8.0% natural condition event NC/IO; 0.1% high water	Incident datetime	Yes; incident datetime
	NSW NPWS	cause = 'Smoking'	100% other	100% lightning	Ignition date	No
	SFNSW	cause = 'Pipe, cigarette, match'	100% other	100% lightning	Start date	Yes; weather, time
Vic	MFB	Form of heat of ignition division = 'Heat from smokers' materials'	90% accidental; 0.3% incendiary; 7% suspicious; 2% unknown	11.8% lightning; 17.6% high wind; 67.2% natural condition event NC/IO; 3.3% high water	Alarm datetime	Yes; alarm datetime
	CFA	Ignition Factor = 'Abandoned, discarded material' (Code310)	100% accidental	46.2% lightning; 41.6% high wind; 12.0% natural condition event NC/IO; 0.2% high water	Incident datetime	Yes; incident datetime
	DSE	Cause = 'Pipe, cigarette, match'	100% accidental	100% Lightning	Fire started	No
Qld	QFRS	Form of heat of ignition division = 'Heat from smokers' materials'	75% accidental; 3% incendiary; 9% suspicious; 9% unknown	21.3% lightning; 52.6% high wind; 25.6% natural condition event NC/IO; 0.4% nigh water	Alarm datetime	Yes; alarm datetime
	FPQ	No data		100% lightning	Detected date	Yes; detected time
	QPWS	No data		100% lightning	Fire date	No
SA	SAMFS	Form of heat of ignition division = 'Heat from smokers' materials'	Not applicable	Not applicable	Incident date	Yes; alarm time
	SACFS	Cause = 'Matches, smoking devices, candles, lanterns' or 'Heat from smokers materials'	16.8% accidental; 30.5% incendiary; 5.3% suspicious; 46% other	56.9% lightning; 29.3% heat from natural source	Alarm date	Yes; alarm time
	SADEH			100% lightning	Fire started date	No
WA	FESA	Form of heat of ignition division = 'Heat from smokers' materials'	40% accidental; 3% incendiary; 26% suspicious; 29% unknown	9.7% lightning; 20.0% high wind; 69.3% natural condition event NC/IO; 0.9% high water	Alarm datetime	Yes; alarm datetime
	WADEC	No data		100% lightning	Detection date	Yes; detection time
Tas	TFS	Ignition Factor = 'Abandoned, discarded material' (Code 310)	100% accidental	23.4% lightning; 56.8% high wind; 19.4% natural condition event NC/IO; 0.5% high water	Incident datetime	Yes; incident datetime
NT	NTFRS	Form of heat of ignition division = 'Heat from smokers' materials'	56% accidental; 1.7% incendiary; 29% suspicious; 12% unknown	40.5% lightning; 33.3% high wind; 26.2% natural condition event NC/IO	Alarm date	Yes; alarm time
ACT	ACT PCL	No data		100% lightning	Fire date	No

Table 4: Summary of databases and variables used in analysis – part three

		Location information	Post code	Tourism Region	Region based on variable	Region classification based on variable	Fire restrictions	Fire danger index	Area burned	Vegetation	Tenure
NSW	NSWFB	Statistical local area; postcode	Yes	Yes	Postcode	Postcode	No	No	No	No	No
	NSWRFS	Incident location; RFS-FCC	No	Yes	Incident location (suburb); RFS FCC	Incident location (suburb); RFS FCC	No	No	Yes	Yes	No
	NSW NPWS	Region; location name; LGA; electorate; long/lat; reserve	No	No	Reserve name	Reserve name (derived from 'Reserve')	No	No	Yes	No	Yes
	SFNSW	Site id; fire name; location	No	No	Site location (modified)	Site location (modified)	No	Insufficient information	Yes	No	Yes
Vic	MFB	Statistical local area; postcode	Yes	Yes	Postcode	Postcode	Yes	Yes	Yes	Yes (but not used)	No
	CFA	Suburb; AMG coordinates	No	Yes	Suburb	Suburb	Yes	No	Yes	Yes	No
	DSE	Fire region; fire district; latitude-longitude	No	No	Fire region	Fire region	No	No	Yes	Yes (but not used)	Yes
Qld	QFRS	Statistical local area; postcode	Yes	Yes	Postcode	Postcode	Yes	Yes	Yes	Yes (but not used)	No
	FPQ	District; logging area	No	No	District	District	No	Yes	Yes	Yes	Yes
	QPWS	Georefs; reserve name	No	Yes	Reserve name	Reserve name	No	No	Yes	No	Yes
SA	SAMFS	Station; incident suburb	No	Yes	Incident suburb	Incident suburb	No	No	No	No	No
	SACFS	Location	No	No	Region	Location	No	No	Yes	Yes	No
	SA DEH	District; region; reserve	No	Yes	Reserve (suburb)	Region	No	No	Yes	No	No
WA	FESA	Postcode	Yes	Yes	Postcode	Postcode	Yes	Yes	Yes	Yes (but not used)	No
	WADEC	Region; division; fire name; AMG coordinates	No	No	Region	Region	No	Yes (numerical)	Yes	Yes	Yes
Tas	TFS	Suburb; postcode	Yes	Yes	Suburb	Suburb	No	No	Yes	Yes	No
NT	NTFRS	Suburb	No	Yes	Suburb	Suburb	No	No	Yes	Yes	No
ACT	ACT PCL	Reserve; district; ACT PCL district	No	No	District	District	No	No	Yes	No	No

a: but includes comparisons with older data from Davies 1997 b: 1998–99 to 2000–01 variably incomplete due to industrial action c: two databases combined d: but principally 2000–01 and 2001–02 e: change in database structure mid way through the reporting interval f: but incomplete g: only available for 1975 to 2001 h: also included information about the drought index; humidity; temperate; wind strength; wind direction; average fuel weigh i: NC not classified; I/O, = insufficient information to classify further

Cause

There was at least one variable relating to the cause of each vegetation fire provided for each database analysed. The level of detail varied markedly between AIRS and non-AIRS databases.

The complexity of the AIRS database, and discrepancies between the causal information provided by agencies – both between AIRS and non-AIRS databases and across different AIRS database – meant that is was necessary to develop a causal classification scheme that summarised the most pertinent aspects of the principal causes of vegetation fires across Australia. Two levels of cause were generated – the cause category (see below), and deliberate versus non-deliberate.

More specific aspects of the cause of fires have also been analysed, including summaries of categories within the ignition factor and/or form of heat of ignition variables in the case of AIRS databases, or specific causal categories provided in non-AIRS databases. The methodology behind these simplifications and the specific impact that this has on some variables are outlined in detail below.

Cause category

The cause category incorporates seven classes of cause, including accidental, incendiary, suspicious, natural, reignition/exposure/prescribed burn, other and unknown. Although this cause classification was generated for all databases, there are some differences between AIRS and non-AIRS databases, and also between non-AIRS databases for which there were fundamental differences in the structure of the data provided. The method used to define the cause category for individual databases are outlined below, together some of the implications of using this classification system.

AIRS databases

The cause category for AIRS databases was defined using the 'ignition factor' variable, as follows:

Accidental: includes AIRS codes 300 to 390 (relating to 'misuse of heat of ignition'), 400 to 490 ('misuse of material ignited'), 500 to 590 ('mechanical failure, malfunction), 600 to 690 ('design, construction and installation deficiencies'), 700 to 790 ('operational deficiencies'), and 960.

Incendiary: AIRS codes 100 to 190; incendiary fires that occurred during and outside civil disturbances.

Suspicious: AIRS codes 200 to 290; suspicious fires that occurred during and outside civil disturbances.

Natural: AIRS codes 800 to 890; includes any natural condition or event – high wind, earthquake, high water including floods, lightning, or any other natural condition not classified, or where there was insufficient information to classify further.

Reignition/exposure: AIRS codes 920 to 935; includes rekindling from a previous fire, cases where a separate removed/detached/adjoining/protected exposure catches alight. Note that in contrast to that used for some other databases land management databases, for agencies using the AIRS classification, this category does not include data from prescribed burns.

Other: AIRS codes 900 to 910, and 990; this includes fires started by animals, as well as any cases the cause of the fire is not classified above, or there was insufficient information to classify further.

Unknown: includes instance where ignition factor was listed as not applicable, undetermined, not reported, and there were missing values.

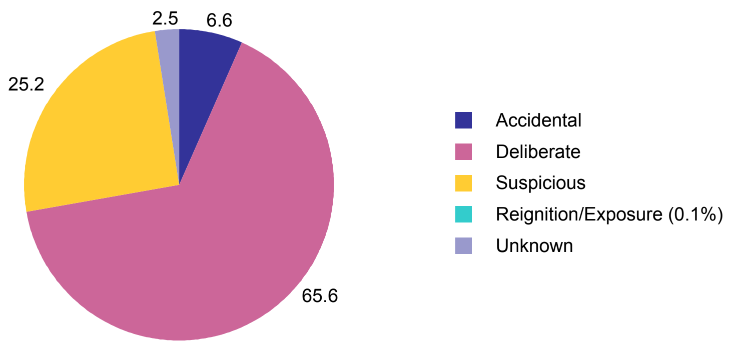
The correlation between specific ignition factor codes and the causal category is outlined in Table 5. The only exception to the classification scheme adopted above was for the South Australia Metropolitan Fire Service.

As noted previously, the only information available for the SAMFS analysis was vegetation fires for which the ‘activity in the area’ was designated ‘malicious’. Although a large overlap obviously exists, not all fires classified as associated with malicious activity were classified as incendiary or suspicious within the ignition factor variable. Notably, only 65.6 percent of wildfires (AIRS definition) where there was malicious activity in the area were classified as incendiary based on the ignition factor code (Figure 1). A further 25.2 percent were suspicious. Collectively, 90.8 percent of SAMFS wildfires associated with malicious activity would have been classified as deliberate according to the causal classification scheme used in this report.

A similar analysis conducted on fires attended by the CFA revealed that only 90 percent of those vegetation fires associated with malicious activity were labelled incendiary or suspicious within the ignition factor variable. It is also evident from the CFA data that there are instances of fires labelled incendiary or suspicious within the ignition factor code, but the activity in the area was not labelled malicious. The SAMFS and CFA data highlight that some mismatch is likely to exist between the information provided by the ignition factor and activity in the area variables. The implication is that neither in isolation is likely to detect all deliberate or malicious fires.

In an attempt to maximise the number of fires available for analysis, and given the considerable discrepancies that already existed between the analyses of the SAMFS and other databases, the SAMFS analysis incorporated all vegetation fires associated with malicious activity, even though not all such fires would have strictly been classified as deliberate according to guidelines used for other AIRS databases.

Figure 1: Causal classification of SAMFS wildfires associated with malicious activity



Source: SAMFS (1997–98 to 2005–06) [computer file]

Table 5: Ignition factor codes defined in the AIRS database

AIRS ignition factor codes		Cause category
Incendiary, legal decision or physical evidence indicates that the fire was deliberate lit		
110	Incendiary, not during civil disturbance	Incendiary
120	Incendiary, during civil disturbance	Incendiary
Suspicious circumstances indicate the possibility that the fire may have been deliberately lit, separate, unrelated fires were found, or there were suspicious circumstances and no accidental or natural ignition factor could be found		
210	Suspicious, not during civil disturbance	Suspicious
220	Suspicious, during civil disturbance	Suspicious
Misuse of heat of ignition		
310	Abandoned, discarded material. Included are discarded cigarettes and cigars	Accidental
320	Thawing	Accidental
330	Falling asleep	Accidental
340	Inadequate control of open fires. Included is smoking out animals and insects	Accidental
361	Children: child playing 0–5 years old	Accidental
362	Children: child playing 6–12 years old	Accidental
363	Children: child playing 13–16 years old	Accidental
371	Unconscious	Accidental
372	Mental impairment	Accidental
373	Physical impairment	Accidental
374	Affected by drugs	Accidental
375	Intoxication by alcohol	Accidental
370	Unconscious, mental or physical impairment, drug, alcohol stupor, insufficient information available to classify further	Accidental
390	Misuse of heat of ignition not classified above	Accidental
300	Misuse of heat of ignition; insufficient information to classify further	Accidental
Misuse of material ignited		
410	Fuel spilled, released accidentally	Accidental
420	Improper fuelling technique	Accidental
430	Flammable liquid used to kindle fire	Accidental
440	Washing part, cleaning, refinishing, painting	Accidental
450	Improper container	Accidental
460	Combustible too close to heat	Accidental
481	Children: child playing 0–5 years old	Accidental
482	Children: child playing 6–12 years old	Accidental
483	Children: child playing 13–16 years old	Accidental
490	Misuse of material ignited not classified above	Accidental
400	Misuse of material ignited; insufficient information to classify further	Accidental
Mechanical failure, malfunction		
510	Part failure, leak, break	Accidental
520	Automatic control failure. Included are delayed ignitions of oil burners	Accidental
530	Manual control failure	Accidental
540	Short-circuit, ground fault	Accidental
550	Other electrical failure	Accidental
560	Lack of maintenance, worn out	Accidental
570	Backfire. Included are ignitions outside of the combustion chamber. Excluded are fires originating as a result of hot catalytic converters (610)	Accidental
590	Mechanical failure, malfunction not classified above	Accidental
500	Mechanical failure, malfunction; insufficient information available to classify further.	Accidental

Table 5: Ignition factor codes defined in the AIRS database (continued)

AIRS ignition factor codes		Cause category
Design, construction, installation deficiency		
610	Design deficiency	Accidental
620	Construction deficiency	Accidental
630	Installed too close to combustibles	Accidental
640	Other installation deficiency	Accidental
650	Property too close to other heat source	Accidental
690	Design, construction, installation deficiency not classified above	Accidental
600	Design, construction, installation deficiency; insufficient information available to classify further	Accidental
Operational deficiency		
710	Collision, overturn, knock over	Accidental
720	Accidentally turned on, not turned off	Accidental
730	Unattended	Accidental
740	Overloaded	Accidental
750	Spontaneous heating	Accidental
760	Improper start-up, shut-down procedures	Accidental
770	Failure to clean. Included is a fouled flue	Accidental
790	Operational deficiency not classified above	Accidental
700	Operational deficiency; insufficient information to classify further	Accidental
Natural condition/event		
810	High wind	Natural
820	Earthquake	Natural
830	High water, including floods	Natural
840	Lightning	Natural
890	Natural condition/event not classified above	Natural
800	Natural condition/event; insufficient information available to classify further	Natural
Other ignition factor		
910	Animal	Other
920	Re-kindled from a previous fire	Reignition/Exposure
931	Separate, removed exposure	Reignition/Exposure
932	Separate, detached exposure	Reignition/Exposure
93[3]	Separate, adjoining exposure	Reignition/Exposure
934	Attached, protected exposure	Reignition/Exposure
935	Attached, unprotected exposure	Reignition/Exposure
960	Vehicle	Other
990	Other ignition factor not classified above	Other
900	Other ignition factor; insufficient information available to classify further	Other
Undetermined or not reported		
008	Ignition factor not applicable	Unknown
000	Ignition factor undetermined	Unknown
Blank	Ignition factor not reported	Unknown

Non-AIRS databases

Causal classification of fires for agencies that did not using AIRS proceeded along very different lines, and varied between agencies depending on the exact structure of the incidence data provided. The name of the cause variable provided that was used to define the cause category variable is outlined for each agency in Table 4. The relationship between the categories within the cause variable provided and the cause category generated there from are outlined for individual agencies in Tables 6 to 16

New South Wales State Forests: The correlations between the causal information provided and the cause category are summarised in Table 6.

Table 6: Cause provided and cause category used for New South Wales State Forests data

Code	Cause (provided)	Cause category (generated)
0	. (Missing)	Unknown
1	Lightning	Natural
2	Machinery	Accidental
3	Pipe, cigarette, match	Other
4	Cooking/heating/camp fire	Accidental
5	Train	Accidental
6	SF Prescribed burning	Prescribed burn
7	NPWS Prescribed burning	Prescribed burn
8	DBFS Prescribed burning	Prescribed burn
10	State Rail Authority burning	Prescribed burn
11	Incendiarism	Incendiary
12	Other rural burning	Other
13	Electricity transmission	Accidental
14	Waste disposal industrial/domestic	Accidental
15	Burning by other public authority	Prescribed burn
99	Other, please specify	Other

NSW National Parks and Wildlife Service: The correlations between the causal information provided and the cause category are summarised in Table 7.

Table 7: Cause provided and cause category used for New South Wales National Parks and Wildlife Service data

Code (provided)	NSW NPWS cause (provided)	Summarised cause (generated)	Cause category (generated)
BOL	Burning off – legal	Burning off – legal	Accidental
CC	Camp/cooking	Domestic/recreational	Accidental
PL	Power line	Facilities	Accidental
FE	Farm equipment	Industry/farming	Accidental
BOL/RIG	Burning off – legal (reignition)	Reignition	Accidental
A	Arson	Arson/suspicious	Incendiary
A/BOL	Arson/burning off – legal	Arson/suspicious	Incendiary
A-MV	Arson – motor vehicle	Arson – motor vehicle	Incendiary
BOI	Burning off – illegal	Burning off – illegal	Incendiary
BOI (A)	Burning off – illegal (arson)	Burning off – illegal	Incendiary
AS	Arson suspected	Arson/suspicious	Suspicious
AS-MV	Arson suspected – motor vehicle	Arson – motor vehicle	Suspicious
L	Lightning	Lightning	Natural
L?	Suspected lightning	Lightning	Natural
RIG	Re-ignition	Re-ignition	Re-ignition
D	Domestic	Domestic/recreational	Other
RT	Rubbish tip	Facilities	Other
T	Trains	Facilities	Other
I	Industrial	Industry/farming	Other
SAW	Sawmill	Industry/farming	Other
MV	Motor vehicle	Motor vehicle	Other
MIS	Miscellaneous (known)	Other	Other
MIS (spot over)	Miscellaneous (spot fire)	Other	Other
MIS (spot fire)	Miscellaneous (spot fire)	Other	Other
MIS (Smouldering logs/trees)	Re-ignition	Re-ignition	Re-ignition
SMO	Smoking	Smoking	Other
HR	Unknown	Unknown	Other
MIS (FLA)	Miscellaneous (unknown)	Unknown	Other
??????	Unknown	Unknown	Unknown
U	Unknown	Unknown	Unknown

Victorian Department of Sustainability and the Environment (DSE): The DSE analysis was undertaken in a manner that attempted to be consistent with the analysis used elsewhere in this report, but to maintain the same causal categories adopted by Davies (1997) in his report on DSE data for the period from 1976–77 to 1995–96 (denoted as FMB Cause in Table 8), to enable consistent evaluation of long-term changes in fire cause for that agency. The analysis of the DSE data presented in this study concentrated on the 1993–94 to 2003–04 period, but where possible, data or trends from Davies (1997) are included to provide a greater overview of long-term variations of bushfire activity on or near Victorian public lands. The relationship between the cause provided, FMB cause and cause category is outlined in Table 8.

Table 8: Cause provided and cause category used for Victorian Department of Sustainability and the Environment data

Cause (provided)	FMB cause (generated)	Cause category (generated)
Burning vehicle, machine	Deliberate	Incendiary
Deliberate lighting (malicious)	Deliberate	Incendiary
Burning off (railway)	Escapes – burning	Accidental
Burning off (stubble, grass, scrub)	Escapes – burning	Accidental
Burning off (windrow, heap)	Escapes – burning	Accidental
Relight-burning off	Escapes – burning	Accidental
Waste disposal, domestic	Escapes – burning	Accidental
Waste disposal, industrial, sawmill, tip	Escapes – burning	Accidental
Campfire, barbeque	Escapes – campfire, BBQ	Accidental
Exhaust, chainsaw	Machines	Accidental
Exhaust, other	Machines	Accidental
Snigging, hauling	Machines	Accidental
Pipe, cigarette, match	Pipe, cigarette, match	Accidental
Power transmission	Public utilities	Accidental
Train	Public utilities	Accidental
Lightning	Lightning	Natural
Burning building	Miscellaneous	Other
Burning house, stove, flue	Miscellaneous	Other
Fireworks	Miscellaneous	Other
Other	Miscellaneous	Other
Relight – wildfire	Miscellaneous	Other
Burning off (departmental prescribed)	Departmental burns	Re-ignition/prescribed burn
Relight-prescribed fire	Departmental burns	Re-ignition/prescribed burn
Null	Unspecified	Unknown
Unknown	Unspecified	Unknown

Forestry Plantations Queensland: The correlations between the causal information provided and the cause category are summarised in Table 9.

Table 9: Cause provided and cause category used for Forestry Plantations Queensland data

FPQ cause	Causal category
Accidental: all reasonable care taken, unlucky accident	Accidental
Accidental: carelessness	Accidental
Accidental: gross negligence	Accidental
Accidental: reasonably foreseeable; event due to stupidity or incompetence	Accidental
Intentional: illegal attempts at hazard reduction burning	Incendiary
Intentional: malicious incendiarism	Incendiary
Intentional: mischief making	Incendiary
Intentional: torching abandoned/stolen vehicle	Incendiary
Intentional: unknown but suspected	Suspicious
Accidental: act of God (e.g. lightning)	Natural
Accidental: unknown, not suspected	Unknown

Queensland Parks and Wildlife Service: The classification of QPWS fires was based on the QPWS cause variable provided, although for fires classified as resulting from arson, both the cause and cause certainty variable were used. The methodology used for the QPWS analysis is summarised in Table 10.

Table 10: Causal category generated and the QPWS 'Cause' and 'Cause certainty' variables

Causal category	QPWS cause	Cause certainty
Accidental	Escaped other burn	Known and suspected
Accidental	Escaped other burn	Known and suspected
Accidental	Machinery/equipment	Known and suspected
Incendiary	Arson	Known
Suspicious	Arson	Suspected
Natural	Lightning	Known and suspected
Re-ignition/PB	Escaped QPWS burn	Known and suspected
Re-ignition/PB	Re-ignition	Known and suspected
Other	Other	Known and suspected

South Australia Country Fire Service: The SACFS dataset incorporated two variables regarding the cause of fires, namely, the 'cause' and 'additional factors' variables. Fires were classified into the seven-tiered causal category used elsewhere based on the 'additional factor category' as outlined in Table 11. However, in many instances, discrepancies existed between the 'cause' and 'additional factors' variables. Attempts were made to correct these anomalies. For example, based on the additional factor variable the majority of fires started by lightning strikes were classified as accidental. These were subsequently recoded as a 'Natural condition or event'. There were 1,287 cases of where the cause was listed as 'unknown – suspected human' but in the additional factors, they were classified as 'malicious'. These fires were categorised suspicious.

There are potentially a number of other anomalous cases where no attempt was made to correct or alter the data. For example, fires started by a bird scarer were labelled 'malicious' and 'misadventure' for two and one cases respectively. There were several cases where no cause was provided but the additional factor was listed as accidental, children, malicious and other factor. For some categories, such as burn offs the situation was complex. Within the burning off category there are three subdivisions, 'Burning and burn offs – with permit', 'Burning and burn offs – without permit or out of fire danger season' and 'Burning off – permit unknown'. Clearly, some burn offs are the result of accidents, some burns are conducted without a permit during the bushfire danger period and may be illegal. There were 24 instances where 'Burning and burn offs – with permit' was considered malicious and 12 cases were it was attributed to misadventure. That burning off with a permit was considered malicious is not unrealistic if burning was undertaken without due regard for the possibility of escape even though a permit had been obtained. There was one case where a harvesting related fire was viewed as misadventure, another where static electricity build-up was determined to be malicious. Again, these attributions may correct in light of the particular circumstances associated with each fire. Other cases where some confusion arises in the interpretation of fires are those pertaining to the re-kindling of a fire. There were two, six, and 12 cases where rekindling was attributed to fires started by children, malicious causes and misadventure respectively. It is unclear in this instance if such attributions refer to the cause of the original fire or these are genuine classification errors. Instances where there are potentially misclassifications are outlined in Table 12.

Table 11: 'Additional factor' variable provided and cause category used for South Australia Country Fire Service data

Additional factors (provided)	Cause category (generated)
Incendiary, deliberate	Incendiary
Malicious	Incendiary
Suspicious circumstances	Suspicious
Accidental	Accidental
Design, installation deficiency	Accidental
Mechanical failure, malfunction	Accidental
Misadventure	Accidental
Operational deficiency	Accidental
Natural condition/event	Natural
Children	Other
Misuse of heat ignition	Other
Misuse of material ignited	Other
Other factor	Other
None	Unknown
Undetermined	Unknown

Table 12: Cause (column) and additional factors (row) for SACFS data with potentially anomalous classifications

Cause	Missing	Accidental	Children	Malicious	Misadventure	Natural condition/ event	Operational deficiency
Bird scarer/rabbit fumigator/other vermin control device				2			
Burning and burn offs – with permit				24			
Cooking/food preparation				1			
Electrical – powerlines					2		
Fireworks				13			
Harvesting – static electricity				1			
Heat from electrical equipment arcing, overloaded						5	
Heat from natural source							2
Mechanical cutting tool/ welders				2			
Missing	143	3	1	1	1		
Rekindle			2	6			
Rekindle					12		
Vehicle – other				5			
Vehicle – other					2		
Vehicle exhaust (not harvest)					3		
Vehicle exhaust (not used in harvesting)				2			

South Australia Department of Environment and Heritage: The SADEH dataset was generated by merging two individual datasets that covered the intervals from 1975 to 2001 and 2001 to 2004. Although both datasets incorporated a cause variable that was consistent across the two datasets, this variable incorporated comparatively few types of cause.

More specific information about causes of fires was listed within the 'comments' field for the 1975 to 2001 data, but not the 2001 to 2004 data. In order to preserve a consistent method of classification across the combined dataset, the causal classification for the SADEH is largely based on the 'cause' variable (Table 13). All fires where the cause was listed as arson were classified as incendiary. However, all fires within the 1975 to 2001 dataset, where the comment variable = 'Original cause description (July 2003): Suspected arson' have been classified as suspicious within the sevenfold causal classification scheme, and as deliberate within the deliberate versus non-deliberate classification scheme. No attempt was made to integrate other specific causal information into the sevenfold causal classification structure using the comment variable for the 1975 to 2001 data. One of the implications of this methodology is that many fires that would normally be classified as accidental were classified as 'other' within the SADEH analysis.

The causal information presented in the Comment variable for 1975 to 2001 is used in some aspects of the analysis. The information within the comments variable has been summarised to yield the 'detailed cause' variable. The relationship between the detailed cause variable, the cause category variable and the comment variable for the SADEH 1975 to 2001 data is summarised in Table 14.

Table 13: Cause provided and cause category used for South Australia Department of Environment and Heritage data

Cause (provided)	Cause category (generated)
Arson	Incendiary
Campfire	Accidental
Escape from prescribed burn	Re-ignition/Prescribed burn
Lightning	Natural
Other	Other
Unknown	Unknown

Table 14: Cause classification of 1975 to 2001 SADEH fires based on 'Comment' variable

Comment (provided): original cause description	Detailed cause (generated)	Causal category (generated)
Agricultural machine	Agric. machinery/power tool	Other
Barbeque	Barbeque	Other
Children with matches	Children	Other
Cigarette or match	Cigarette or match	Other
Escape from burning window (Other organisation)	Escape from burning window (Other organisation)	Other
Exhaust system	Exhaust system	Other
Incinerator	Rubbish/Incinerator	Other
Neighbour burning off scrub	Neighbour burning	Other
Neighbour burning off stubble	Neighbour burning	Other
Possible rekindle	Rekindle	Other
Possibly children	Children	Other
Rubbish tip	Rubbish/Incinerator	Other
Spark from powerline	Power line	Other
Spark from power tool	Agric. machinery/power tool	Other
Spark from welder	Agric. machinery/power tool	Other
Train – brake shoe	Train – brake shoe	Other
(July 2003): Not recorded		Unknown
(July 2003): Other	Other	Other
(July 2003): Rekindle	Rekindle	Other
(July 2003): Spark from machinery	Agric. machinery/power tool	Other
(July 2003): Suspected arson		Suspicious

Department of the Environment and Conservation (WA): The correlations between the causal information provided and the cause category are summarised in Table 15. In addition to the above, where the cause provided was 'unknown' or 'cause not listed' but for which an offence was suspected in the 'Offence suspected' variable, fires were classified as suspicious.

Table 15: Cause provided and cause category used for Western Australian Department of the Environment and Conservation data

DEC fire cause description	Cause category
Accidental by other industry	Accidental
Accidental by recreational forest users	Accidental
Accidental by timber industry	Accidental
Escape from other burning off (not CALM[a])	Accidental
Deliberate	Incendiary
Lightning	Natural
Escape from CALM prescribed burn	Reignition/Prescribed burn
Cause not listed	Unknown
Unknown	Unknown

a: CALM refers to Department of Conservation and Land Management, which has subsequently been incorporated into the Department of the Environment and Conservation.

Australian Capital Territory Forests: The correlations between the causal information provided and the cause category are summarised in Table 16.

Table 16: Cause provided and cause category used for ACT Parks Lands and Conservation database

Ignition factor	Cause category
Accident	Accident
BBQ	Accident
Arson	Incendiary
Lightning	Natural
Prescribed burn	Re-ignition/PB
Prescribed burn (Re-ignition)	Re-ignition/PB
Re-ignition	Re-ignition/PB
Other	Other
Unknown	Unknown

Deliberate versus non-deliberate

The cause categories above have been recombined to yield three categories:

- **non-deliberate**: includes accidental, natural, re-ignition/exposure, spot-over and 'other' causes
- **deliberate**: includes both incendiary and suspicious fires
- **unknown**: includes all those fires listed in the above category as unknown.

Ignition factor summary

In instances where the 'form of heat of ignition' variable was not available for AIRS databases (see Table 4), the ignition factor data were summarised to yield a classification that provided more specific information about the causes of fires, without becoming bogged down in the myriad of causes that potentially may lead to a vegetation fire. The summarised variable is referred in this report to as the 'ignition factor summary'.

The ignition factor summary variable was used in the analysis of the NSW Rural Fire Service, Tasmanian Fire Service and the Victorian Country Fire Service data, and is based on the divisional headings outlined in the AIRS handbook (AFAC 1997), namely 'incendiary', 'suspicious', 'misuse of heat ignition', 'misuse of material ignited', 'mechanical failure, malfunction', 'design, construction, installation deficiency', 'operation deficiency', 'natural condition', 'other' and 'unknown'. However, the suspicious and incendiary fires have been combined into a single category titled 'deliberate'. In the case of both the TFS and NSWRFS data no indication was made whether fires attributed to children resulted from the misuse of heat of ignition or from the misuse of the material ignited, as is the case in the AIRS database. In summarising the ignition factor codes all fires within these databases implicating children for were incorporated into the misuse of heat of ignition category.

Form of heat of ignition

The form of heat of ignition variable was supplied for six agencies employing the AIRS database structure. This includes the four agencies for which data were acquired through AFAC (NSWFB, MFB, QFRS, FESA), the SAMFS and NTFRS.

With the exception of the NTFRS a similar method was used to summarise the form of heat of ignition categories. This was based strictly on the divisional headings outlined in the AIRS database and included the following sub categories:

Heat from fuel-fired, fuel powered object (Fuel-powered object), includes:

- Spark, ember, flame escaping from gas-fuelled equipment
- Heat from gas-fuelled equipment, including pilot lights and normal flames
- Spark, ember, flame escaping from liquid-fuelled equipment
- Heat from liquid-fuelled equipment, including pilot lights and normal flames
- Spark, ember, flame escaping from solid-fuelled equipment
- Heat from solid-fuelled equipment
- Spark, ember, flame escaping from equipment; fuel unknown
- Heat from equipment; fuel unknown
- Heat from fuel-fired, fuel-powered object not classified above
- Heat from fuel-fired, fuel-powered object; insufficient information available to classify further.

Heat from electrical equipment arcing, overload (Electrical), includes:

- Water cause short-circuit arc
- Short-circuit arc from mechanical damage
- Short-circuit arc from defective, worn insulation
- Unspecified short-circuit arc
- Arc from faulty contact, loose connection, broken conductor
- Arc, spark from operating equipment or switch
- Arc from overloaded equipment – included are wires and motors
- Fluorescent light ballast
- Heat from electrical equipment arcing, overload, not classified above
- Heat from electrical equipment arcing, overload; insufficient information available to classify further.

Heat from smokers' materials, including heat from materials in use or after use. Excluded are matches and lighters (450 & 460; smoking-related), includes:

- Cigarette
- Cigar
- Pipe
- Heat from smokers' materials, not classified above
- Heat from smokers' materials; insufficient information available to classify further.

Heat from open flame, spark (Open flame), includes:

- Cutting torch operation (separating metals)
- Welding torch operation (joining metals)
- Torch operation, other cutting and welding, including plumbers' furnaces, blowtorches, plumbers' torches, Bunsen burners, soldering and heating operations, paint stripping torches, drip torches and other torch operations
- Candle, taper
- Match
- Lighter (flame type)
- Camp-fires, including fires for cooking or personal comfort on the ground, in appliances designed for the purpose or in properly constructed fireplaces
- Rubbish fires, including small fires on ground for the disposal of domestic and garden refuse
- Incinerators, including appliances for the burning of domestic and garden refuse
- Bonfires
- Burn-off fires, including burn-off of grass, crops and scrub for agricultural purposes. Usually associated with the clearing of land. Also includes the use of fires for fuel reduction/wildfire prevention purposes
- Windrows, slash/fire, including large scale burning of heaps of materials. Generally associated with the forest industry and land clearing
- Open fires, not classified above
- Open fires, not classified above
- Open fires, insufficient information available to classify further
- Backfire from internal combustion engine, excluding flames and sparks from exhaust system (130)
- Heat from open flame, spark not classified above
- Heat from open flame, spark; insufficient information available to classify further.

Heat from hot object or friction (Hot object/friction), includes:

- Heat, spark from friction, including overhead tyres, slipping drive belts
- Molten, hot material, including molten metal, hot forging, and hot glass
- Hot ember, ash
- Electric lamp, including light bulbs
- Re-kindle, re-ignition
- Heat from properly operating electrical equipment
- Heat from improperly operating electrical equipment

- Heat from hot objects or friction not classified above
- Heat from hot objects or friction; insufficient information available to classify further.

Heat from explosives/fireworks (Explosives/fireworks), includes:

- Munitions, including bombs, ammunition and military rockets
- Blasting agent, primer cord, black powder fuse, including ammonium nitrate, when used as an explosive
- Fireworks, including sparklers
- Paper cap, party popper
- Model rocket and amateur rocketry
- Incendiary device, including Molotov cocktails
- Heat from explosive, fireworks not classified above
- Heat from explosive, fireworks; insufficient information available to classify further.

Heat from natural source (Natural), includes:

- Sun's heat, usually concentrated
- Spontaneous ignition, chemical reaction
- Lightning discharge
- Static discharge
- Heat from natural source not classified above
- Heat from natural source; insufficient information available to classify further.

Heat spreading from another hostile fire (Exposure)[Hostile fire], includes:

- Heat from direct flame, convection currents
- Radiated heat
- Heat from flying brand, ember, spark
- Conducted heat
- Heat spreading from another hostile fire not classified above
- Heat spreading from another hostile fire; insufficient information available to classify further.

Other form of heat of ignition (Other), includes:

- Microwaves
- Multiple forms of heat of ignition
- Not applicable
- Other forms of heat of ignition not classified in any division above
- Other forms of heat of ignition: ; insufficient information available to classify further.

Undetermined or not reported (Unknown), includes:

- Form of heat of ignition undetermined
- Form of heat of ignition not reported

The form of heat of ignition for the NTFRS differed slightly from that used above. For the most part, the form of heat of ignition was summarised using the divisional headings, as outlined above except that

- 'Heat from smokers materials' division was combined with fires attributed to matches and lighters (originally within the 'Heat from open flame, spark' category) into a single category titles 'Cigarettes, matches, lighters'.
- 'Incendiary device' was removed from the 'Heat from fireworks/explosive' category forming a category by itself titled 'Incendiary'.
- 'Heat from fuel-fired, fuel-powered object' and 'Heat from electrical equipment arcing, overloaded' were combined into a single category titled 'Mechanical, electrical'.
- Fires resulting from 'Torch operation, welding torch and other torch operation' (originally in 'Open flame, spark' division) were incorporated into mechanical, electrical category.
- Categories titled 'Heat from flying brand, ember, spark' and 'Heat from properly operating electrical equipment' were incorporated into the 'Mechanical, electrical category'.
- Fires attributed to 'Burn-off fires' and 'Camp-fires' were extracted from the 'Heat from open flame, spark' categories and formed single categories by themselves.
- 'Other' category includes fires attributed to 'Candle, taper', 'Heat spark from friction', 'Molten, hot material', 'Not applicable', 'Other form of heat of ignition not classed in any division', 'Other forms of heat ignition; I/I to classify further', 'Rubbish fires' 'Windrows/slash/fire'.
- Open flames, re-ignition category incorporated fields: 'Heat from direct flame, convection currents', 'Heat from open flame, spark not classified above', 'Heat from open flame, spark; I/I to classify further', 'Heat spreading from another hostile fire not classified above', 'Open fires not classified above', 'Open fires; insufficient information to classify further' and 'Re-kindle, Re-ignition'.

Implications for the causal classification scheme

There are a number of implications that arise from differences in the structure of the databases provided and the methods employed to summarise the causal data contained within them. Some implications specific to individual databases are discussed above. Three areas where discrepancies arise across databases are for natural fires, smoking-related fires, and in the re-ignition/exposure/prescribed burn category.

Natural fires

There are some subtle differences in the way that natural fires were classified across AIRS and non-AIRS databases. Typically, all fires in non-AIRS databases classified as natural were the result of lightning. However, for AIRS databases, natural fires refer not only to fires started by lightning, but also high wind, earthquake, high water (including floods), or other unspecified natural condition or events (not classified or insufficient information to classify further). However, it is evident from the analysis of some agencies' databases, that incorporated within this category are human-caused fires, where natural conditions have been responsible for the escape but not for the ignition of the fire. Hence, for AIRS databases the 'natural' category may actually overestimate the numbers of fires that resulted from natural ignitions, and actual percentages of natural fires may be somewhat lower. The breakdown of the specific causes of causes of natural fires is outlined in Table 4.

Smoking-related fires

A uniform method for identifying smoking related fires could not be adopted across all agencies. Many of the non-AIRS database structures included an individual category within the cause variable that specifically related to fires starting from cigarettes and other smoking-related materials. The situation for AIRS database was somewhat more complex.

For those agencies for which the 'Form of heat of ignition' variable was available, smoking related fires were based on cases where the 'Form of heat of ignition' = 'Heat from smokers' materials' division. For the agencies where only the AIRS ignition factor was available, smoking related fires refer to all cases where the ignition factor was classified 'abandoned, discarded materials'. Using the databases for which both the form of heat of ignition and the ignition factor were available it is evident that although many of the fires that resulted from 'Heat from smokers' material' (Form of heat of ignition) were subsequently categorised as resulting from the 'Abandoned, discarded material' code within the ignition factor variable, there was no one to one correspondence, as the ignition factor may be listed as incendiary, suspicious, or unknown, among other variables. The extent of the overlap varied markedly between agencies, from 58 to 83 percent (Table 17). Similarly, fires classified as 'Abandoned, discarded material' that were subsequently categorised within the 'Heat from smokers' materials' ('Form of heat of ignition' variable) was not 100 percent, and again varied between agencies. For example, 80 percent of all NSWFB fires where the ignition factor was identified as 'abandoned, discarded materials' were also classified as 'heat from smokers materials' in the form of heat of ignition variable (Table 17). The implications of the above observations are three-fold:

- analyses of cigarette-fires based on abandoned and discarded materials are likely to underestimate the number of smoking related fires by as much as 30 to 50 percent
- smoking-related fires defined on the basis of the form of heat of ignition variable may subsequently be classified as accidental, incendiary, suspicious, other, or unknown within the cause category classification scheme, whereas all smoking related fires defined on the ignition factor alone will be classified as accidental
- smoking-related fires are a problem over and above that posed by deliberate firesetting. The extent of this problem varied markedly between agencies and appeared to be intimately related to population density.

The variables used to categorise smoking-related fires for each database, and their classification with the cause category structure is outlined in Table 4.

Table 17: Fires in the Heat from smokers' material division and those classified as Resulting from abandoned or discarded materials in the ignition factor variable (percent)

	NSWFB	MFB	QFRS	FESA
'Heat from smoker materials' subsequently classified with the 'Abandoned, discarded materials' (ignition factor) category	72.4	83.1	57.8	45.6
'Abandoned, discarded materials' (ignition factor) category that were classified as 'Heat from smoker materials'	80.0	95.3	75.6	88.5

Agent responsible for fires

AIRS database: implications for child fires

The AIRS database does not specifically identify the agent responsible for the fire, with the exception of children. Fires pertaining to children are broken into six categories. This includes three categories each within the 'misuse of heat of ignition' (codes 361–363) and 'misuse of material ignited' (codes 481–483) divisions, pertaining to children with ages from 0 to 5 years, 6 to 12 years, and 13 to 16 years. Hence, in this study 'child' fires refers to all fires started by persons aged 16 years and younger. Many AIRS databases included ignition factor codes of 360 and 480, which were taken to refer to non-deliberate child fires lit by child playing, of unknown age. Moreover, the TFS and NSWRFS did not differentiate between the misuse of heat of ignition and misuse of materials ignited in the database supplied for analysis.

Although the number of fires identified as resulting from children playing is in and of itself a useful statistic, fundamental design flaws within the database prohibit agencies from accurately knowing the number of fires for which children have been identified as being responsible: malicious fires started by children 16 years or younger are classified as incendiary or suspicious. Moreover, there are likely to be numerous fires for which the role of children has not been identified, as they were not observed at the scene.

There are two signification outcomes from the structure of the AFAC (2007):

- It is impossible for individual agencies to access the known incidences of fires started by children 16 years and under, if those agencies record fires in strict accordance with the guidelines outlined in AFAC (1997). This means that, although juvenile intervention programs are implemented in all states and territories in Australia, it is impossible to determine their effectiveness at a gross scale, or to enable targeting of areas of high risk or known problem areas (other than by relying on the anecdotal evidence, retained by fire fighting staff, who may or may not have contact with the educational component implemented by fire services).
- Given that fires started by children are potentially a significant component within the incendiary and suspicious categories, the classification of fires started by children has an important bearing on the actual rates of deliberate versus non-deliberate fires recorded by individual agencies. Differences in the way child fires are attributed across agencies, can lead to marked differences in the recorded levels of deliberate firesetting and pose significant issues for the integration of data between fire agencies (see combined MFB and CFA analysis). In this analysis, differences in the attributions of child fires are reflected in differences in the proportion of accidental versus incendiary or suspicious fires.

Non-AIRS databases

Only two non-AIRS agencies include any information about the agent responsible for ignition.

Victorian Department of Sustainability and the Environment (DSE): The agents responsible for DSE fires have been summarised into the following categories:

- *Children*: Children
- *Government employee*: Employee DSE or PV; Employee NRE; Employee, forestry industry, Employee, other department.
- *Farmer/grazier*: Farmer/farm employee; full-time; Farmer/farm employee part-time; Grazing leaseholder, Farmer/grazier
- *Lightning*: Natural
- *Recreationist*: recreationist, bushwalker; recreationist, camper; recreationist, day visitor; recreationist: day fisherman.
- *Resident*: Resident, part-time; Resident, full-time
- *Traveller*: Traveller
- *Other*: Employee, other industry; military; other
- *Unknown*: Unknown, Null

As the agent responsible for fire is independent from the cause variable, fires attributed to children, like other agents, may be classified as either accidental or deliberate.

South Australian Country Fire Service (SACFS): The SACFS delineate fires started by children within the 'additional factors' variable. Again, because this variable is independent from the cause variable, fires started by children are categorised as accidental, incendiary, suspicious etc within the SACFS analysis.

Location

The amount and type of information about the location of a fire varies markedly across databases. Most variables that specially record information about the location of a fire have been noted in Table 4. In this study, broad geographical distribution of fires was examined by region, as well as smaller geographical units, including statistical regions, statistical local areas, postcodes or suburbs, depending on the structure of the information provided and ease with which information could be most clearly presented. Other variables examined that provide information about the location of a fire, include the type of complex or property use, tenure, point of origin.

Region

Where possible a common regional structure was employed across agencies. The unifying concept adopted was based on the ABS's tourism region. However, it was not possible to adopt this structure for many land management agencies, owing to the structure of the information provided.

Tourism region

Although tourism regions are primarily used to monitor tourism activities, there are several advantages to using this approach in examining the distribution of fires. Using the modified approach adopted here, it was easy to assign large numbers of fires to different regions using either the postcode or suburb name provided. Moreover, tourism regions have been intentionally developed to parallel the regional structure adopted by the tourism industry, and therefore have greater familiarity with a broader audience than units like statistical subdivisions, which are most familiar to those who deal with statistical data. Tourism region maps are included within the discussion for each state and territory, with the exception of the Australian Capital Territory.

In this study, tourism regions were generated using ABS (2005) concordance files. However, fundamental differences exist between the regions outlined in that document and structure adopted herein. Notably, the ABS tourism regions are built from statistical local areas (SLA) which often crosscut individual postcodes or suburbs. In contrast, tourism regions used in this study were assigned to a particular region based on the suburb name and/or postcode variable. Table 4 outlines whether the data were analysed using tourism region, and other variables used to assign individual fires – for example postcode versus suburb. The exact methodology is also discussed at the commencement of each agency's analysis.

In some cases where only the suburb name was provided, it was necessary to generate the postcode variable first. Assignation based on suburb name was complicated in cases where there was more than one suburb of the same name in the same state or territory and use of local names which bear no resemblance to official place names to record information in the database. In these instances, additional information was examined, but if no further clues were available, then these fires were assigned as location unknown.

The correlation between postcodes or suburb and region were assisted by the use of the postcode selector tool incorporated in Decipher Technologies website (http://www.decipher.biz/), which is based on ABS (2005).

For two land management agencies, fires were assigned to a tourism region based on the name of the reserve: the Queensland Parks and Wildlife Service and the South Australian Department of Environment and Heritage.

Queensland Parks and Wildlife Service: Each reserve was allocated to one of the 12 tourism regions, as follows:

- *Brisbane*: includes Bellthorpe Aggregation, Bribie Island Aggregation, Bunyaville Forest Reserve, Carbrook Wetlands Aggregation, D'Aguilar North Aggregation, D'Aguilar South Aggregation, Daisy Hill-Venman Aggregation, Glen Rock Area, Helidon Hills Aggregation, Moogerah Peaks National Park, Moreton Island Aggregation, North Stradbroke Island Aggregation.
- *Bundaberg*: includes Bania Aggregation, Bulburin Aggregation, Calrossie Aggregation, Deepwater National Park, Eurimbula Aggregation, Gurgeena-Nour Nour Aggregation, Pile Gully Aggregation.
- *Darling Downs*: includes Barakula Aggregation, Booroondoo Aggregation, Braemar Aggregation, Bunya Mountains Aggregation, Conloi Aggregation, Dunmore State Forest, Expedition Aggregation, Expedition Range Aggregation, Girraween Aggregation, Kinkora Aggregation, Kumbarilla Aggregation, Main Range Aggregation, Morgan Park Resources Reserve, Nudley State Forest, Sundown Aggregation, Whetstone Aggregation, Western Creek State Forest, Wondul Aggregation, Yelarbon State Forest.
- *Fitzroy*: includes Blackdown Aggregation, Byfield Aggregation, Carnarvon Nogoa Aggregation, Castle Tower Aggregation, Cudmore Aggregation, Kroombit Aggregation, Rundle Range Aggregation.
- *Gold Coast*: includes Lamington National Park – Green Mountains & Southern sections, Mount Barney Aggregation, Nerang Aggregation, South Stradbroke Island Aggregation, Springbrook Aggregation, Tamborine Aggregation.
- *Hervey Bay/Maryborough*: includes Allies Creek State Forest, Cooloola Rainbow Beach Aggregation, Fraser Island Eurong Aggregation, Great Sandy National Park, Great Sandy District, Imbil Aggregation, Mount Walsh Aggregation, Poona Aggregation, Vernon Aggregation, Wigton Aggregation, Wondai Aggregation, Wrattens Aggregation, Yabba Aggregation.
- *Mackay*: Credition State Forest, Dipperu National Park.
- *Northern*: Blackwood National Park, Bowling Green Bay Aggregation, Cape Pallarenda-Townsville Town Common Aggregation, Dalrymple National Park, Lumholtz Southern Aggregation, Paluma Aggregation, Palmer Goldfields Resources Reserve, White Mountains Aggregation.
- *Outback*: Lawn Hill Aggregation, Lochern National Park, Moorrinya National Park, Oakview Aggregation, Porcupine Gorge National Park.
- *Sunshine Coast*: Amamoor Aggregation, Beerburrum Aggregation, Conondale Aggregation, Mapleton Aggregation, Mooloolah River Aggregation, Noosa Aggregation, Parklands Aggregation, Squirrel Aggregation.
- *Tropical North Queensland*: Bulleringa National Park, Cairns (Whitfield-Kamerunga) Aggregation, Cairns Coast Northern Marine Aggregation, Cape Melville National Park, Eubenangee Swamp Aggregation, Forty Mile Scrub National Park, Herberton Range Forest Reserve, Herberton Range Aggregation, Hull River Catchment Aggregation, Iron Range Aggregation, Jardine Aggregation, Koombooloomba Aggregation, Kurrimine Aggregation, Lakefield Aggregation, Lumholtz National Park Western Section, Mitchell and Alice Rivers National Park, Mungkan Kandju Aggregation, Russell River Aggregation, Staaten River National Park, Tully Gorge Aggregation, Tumoulin Aggregation, Undara Volcanic Aggregation, White Rock Aggregation, Wooroonooran National Park – North Section.

- *Whitsundays*: Cape Upstart Aggregation, Conway Aggregation, Mount Aberdeen National Park.

South Australia Department of Environment and Heritage: the specific allocation of individual reserves is outlined below:

- *Adelaide*: Onkaparinga River, Cobbler Creek, Para Wirra, Hackam, Sheperds Hill, Belair, Sturt Gorge, Hallett Cove, Anstey Hill, Mount Osmond, Angove, O'Halloran Hill, Brownhill Creek, Fort Glanville, Windy Point, Moana Sands, Aldinga Scrub, Ferguson.
- *Adelaide Hills*: Cleland, Morialta, Montacute, Greenhill, Horsnell Gully, Scott Creek, Kenneth Stirling, Charleston, Cudlee Creek, Mark Oliphant, Warren, Totness, Black Hill.
- *Barossa Valley*: Kaiserstuhl.
- *Clare Valley*: Redbank, Spring Gully.
- *Eyre Peninsular*: Franklin Harbor, Lincoln, Pureba, Yumbarra, Whittlebee, Lake Newland, Kellidie Bay, Pinkawillinie, Seaford Rise, Heggaton, Coffin Bay, Barwell, Bascombe Well, Carappee Hill, Caratoola, Cocata, Gawler Ranges, Greenly Island, Hambidge, Hincks, Kathai, Kulliparu, Lake Gilles, Laura Bay, Middlecamp Hills, Munyaroo, Sleaford Mere, Verran Tanks, Wanilla, Whyalla, Yalata, Yellabina.
- *Fleurieu Peninsular*: Finniss, Newland Head, Deep Creek, Talisker Conservation, Mount Billy, Cox Scrub, Kyeema, Mount Magnificent, Myponga, Nixon-Skinner, Spring Mount, The Elbow.
- *Flinders Ranges*: Winninowie, Gammon Ranges, Mount Remarkable, The Dutchmans Stern, Flinders Ranges, Mambray Creek, Mount Brown, Telowie Gorge.
- *Kangaroo Island*: Cape Torrens, Western River, Beyeria, Flinders Chase, Beatrice Islet, Cape Gantheaume, Cape Hart, Dudley, Kelly Hill, Lathami, Mount Taylor, Nepean Bay, Parndana, Pelican Lagoon, Vivonne Bay.
- *Limestone Coast*: Carcuma, Fairview, Mud Islands, Gum Lagoon, Messent, Coorong, Bucks Lake, Canunda, Stoneleigh Park Heritage, Desert Camp, Beachport, Belt Hill, Big Heath, Bool Lagoon, Calectasia, Ewens Ponds, Furner, Hacks Lagoon, Kelvin Powrie, Little Dip, Lower Glenelg River, Martin Washpool, Mount Boothby, Mount Monster, Mount Scott, Naracoorte Caves, Padthaway, Penola, Poocher Swamp, Reedy Creek, Tantanoola Caves.
- *Murraylands*: Billiat ,Ngarkat, Swan Reach, Mount Rescue, Brookfield, Karte, Ridley, Roonka, Scorpion Springs, White Dam.
- *Outback*: Innamincka, Witjira.
- *Riverland*: Murray River, Calperum, Danggali, Chowilla, Kapunda Island, Peebinga, , Cooltong, Loch Luna, Maize Island Lagoon, Moorook, Pike River, Pooginook.
- *Yorke Peninsular*: Innes, Warrenbein, Carribie, Clinton, Leven Beach, Point Davenport, Port Gawler.
- *Unknown*: Missing, off park, Other DEH managed land, Redbanks, Weartherspoon's, Unnamed.

South Australia Country Fire Service: Although tourism regions (ABS 2005) were used in the analysis of the SACFS data, there were some limitations to the regional classification of individual fires, as:

- there were 823 cases for which grid reference data was available in the absence of a location name – it was beyond the resources of this project to convert these to a regional classification used elsewhere, and the location of these fires was listed as unknown.
- there were also 171 instances where location information was completely absent.
- location details provided were vague – for example, '100 km north of such-and-such' – the number of cases was comparatively minor.
- more than two locations with the same name existed in South Australia.
- the location name provided did not correspond to the official name of the suburb.

In total there were 1,171 instances (13.6 percent) where the region was not allocated.

Agencies for which tourism regions were not used

It was not possible to use the tourism region model for all databases, as there was insufficient information, the effort required in converting the data was too high, or the large area covered by reserves (in the case of land management agencies) negated the value of that system. The classification schemes adopted for agencies where tourism region were not used are outlined below.

State Forests NSW: The regional location of SFNSW fires was principally recorded under two variables, the site name, which provides the name of the regional office or operations centre, and the variable titled 'label name' which represent a single place name, and presumably corresponded to the name of the local forestry office that provided fire suppression services. Based on the 'label name' provided, fires were assigned to one of 12 regions, as outlined in Table 18, although additional modifications were made with regard to specific reserves (Table 19).

Table 18: Site name, region name provided and region assigned for NSW State Forests data

Site code	Site name (provided)	Label name (provided)	Region (generated)
0	Non State Forest RC	Non SF	Unknown
400	Softwoods Divisional Office	Albury	Murray
401	Macquarie Regional Office (Bathurst)	Bathurst	Explorer Country
403	Oberon Operations Centre	Oberon	Explorer Country
404	Tumbarumba Operations Centre	Tumbarumba	Snowy Mts
405	Hume Regional Office (Tumut)	Tumut	Snowy Mts
419	Walcha Operations Centre	Walcha	North West
421	South Coast Regional Office (Batemans Bay)	Batemans Bay	South Coast
423	Monaro Regional Office (Bombala)	Bombala	Snowy Mts
424	South East Regional Office (Eden)	Eden	South Coast
425	Moss Vale Operations Centre	Moss Vale	Southern Highlands
426	Narooma Operations Centre	Narooma	South Coast
427	Queanbeyan Operations Centre	Queanbeyan	Capital Country
441	Bulahdelah Operations Centre	Bulahdelah	North Coast
442	Hunter Regional Office (Newcastle)	Newcastle	Hunter
444	Gloucester Operations Centre	Gloucester	Hunter
445	Kempsey Operations Centre	Kempsey	North Coast
447	Manning Regional Office (Taree)	Taree	North Coast
448	Macleay/Hastings Regional Office (Wauchope)	Wauchope	North Coast
461	Northern Rivers Regional Office (Casino)	Casino	Northern Rivers
464	Dorrigo Operations Centre	Dorrigo	North Coast
465	Grafton Operations Centre	Grafton	Northern Rivers
466	Glen Innes Operations Centre	Glen Innes	North West
470	Urbenville Operations Centre	Urbenville	Northern Rivers
471	Urunga Operations Centre	Urunga	North Coast
472	Northern Regional Office (Walcha)	Walcha	North West
481	Baradine Operations Centre	Baradine	North West
482	Riverina Regional Office (Deniliquin)	Deniliquin	Riverina
483	Western Regional Office (Dubbo)	Dubbo	Explorer Country
484	Forbes Operations Centre	Forbes	Explorer Country
485	Inverell Operations Centre	Inverell	North West
486	Narrandera Operations Centre – Hardwood	Narrandera–Hardwood	Riverina
487	Narrandera Operations Centre – Cypress	Narrandera–Cypress	Riverina
800	Hardwoods Divisional Office	Grafton	Northern Rivers
801	Mid North Coast Regional Office (Coffs)	Coffs Harbour	North Coast
999	Head Office	Head Office	Sydney

Table 19: Additional changes made to the assignment of region for the SFNSW data	
Reserve name (provided)	**Region (generated)**
Aberdare State Forest	Hunter
Nullica State Forest	Hunter
Mount Mitchell State Forest	Northern Rivers
Moogem State Forest	Northern Rivers
Kanangra Boyd National Park	Sydney
Mummel Gulf	North West

NSW National Parks and Wildlife Service: A region variable, titled ‘region’, was provided with the dataset. Although this variable was used in a limited number of instances, there were inconsistencies in the way the locations were coded for individual reserves. For example, a single reserve could have been classified within several different NPWS regions (as defined in the data). In some cases this may reflect reality where, due to their large extent some parks can extend across region boundaries. In other cases, the classification system was not consistent with zone boundaries. The classification scheme adopted in the study drew on the regional domains defined by the NSW NPWS on their website http://www.nationalparks.nsw.gov.au/. The allocation of fires to a particular region was based on the name of the reserve. In instances where fires occurred off park but the name of the park was included, the fire was attributed to that reserve in the ‘Reserve’ variable, and the regional attribution made accordingly. In the absence of information about the reserve name, fires were allocated to a region based on other location information (see Table 4), including the local government area, electorate etc. Wherever the original ‘region’ variable was used in the NSW NPWS analysis, data were cleaned to remove inconsistencies.

The allocation of reserves into individual regions is outlined below:

- *Central NSW*: Abercrombie River NP, Arakoola NR, Avisford NR, Binnaway NR, Cataract NP, Cocoparra NP, Conimbla NP, Coolah Tops NP, Coolbaggie NR, Coppermania NR, Goobang NP, Goulburn River NP, Gurranang Crown Rese, Hill End Historic site, Kirramingly NR, Macquarie Marshes NR, Mt Canobolas SCA, Mt Kaputar NP, Mullion Range SRA, Munghorn NR, Nangar NP, NAP Rocky Glen, Narran Lake NR, Pilliga NP, The Rock NR, Timmallie SF, Turon NP, Warrumbungles NP, Weddin Mtns NP, Winburndale NR, Wombat Creek CR, Yuranighs Ab Grave.
- *Hunter & MNC*: Arakoon NR-Hat Head NP, Awabakal NR, Baalijin NR, Bago Bluff NP, Barakee NP, Barrington Tops NP, Bellinger River NP, Ben Halls Gap NP, Bindarri NP, Biriwal Bulga NP, Bollanolla NR, Bongil Bongil NP, Boonanghi NR, Booti Booti NP, Bowraville NR, Bretti NP, Bugan NR, Cascade NP, Cedar Brush NR, Clenrder SRA, Clybucca HS, Coolongolook NR, Cooperabung Range NR, Coorabakh NP, Copeland Tops SRA, Crowdy Bay NP, Darawank NR, Dorragan NP, Dorrigo NP, Dunggir NP, Fishermans Bend NR, Ganay NR, Garby NR, GFRNP, Ghin-doo-ee NP, Glenrock SRA, Hexham Swamp NR, Jagun NR, Jasper NR, Junuy Juluum NP, Juugawaarri NR, Karuah NR, Khappinghat NP, Killabakh NR, Kooragang Island NR, Kumbatine NP, Lake Innes NR, Lake Macquarie SRA, Limeburners Creek NP, Lower Hunter NP, Macquarie NR, Maria NP, Monkerai NR, Monkeycot NR, Moonee Beach NR, Mt Royal NP, Myall Lakes NP, Ngambaa NR, North Brother, Nymboi-Binderay NP, Pambalong NR, Pickett Hill Aboriginal, Pulbah Island NR, Queens Lake NR, Rawdon Creek NR, Running Creek NR, Seaview NR, Singleton, Skillion NR, Snapper Island NR, Talawahl NR, Tapin Tops NP, The Glen NR, Tingira Heights NR, Tomalla Nature Reser, Tomaree NP, Tomaru NP, Towarri NP, Ulidarra NP, Valla Beach NR, Wallabadah NR, Wallamba, Wallarah NP, Wallaroo NR, Wallingat NP, Watagans NP, Willi Willi NP, Woko NP, Worimi NR, Yarravel NR.

- *New England Tablelands*: Bagul Waajaarr NR, Bald Rock NP, Barool NP, Bluff River NR, Bolivia Hill NR, Boonoo Boonoo NP, Boorolong NR, Butterleaf NP, Capoompeta NP, Carrai NP, Cathedral Rocks NP, Chaelundi NP, Cottan-Bimbang NP, Coutts Crown NR, Cunnawarra NP, Dalmorton SF, Ellis SF, Georges Ck NR, Gibraltar Range NP, Guy Fawkes River NP, Hewitts Peak NR, Indawarra NP, Ironbark NR, Jobs Mountain NR, Kings Plains NP, Kwiambal NP, Mann River NR, Moonpar SF, Mt Hyland NR, Mt McKenzie NR, Mt Yarrowyck NR, Mummel Gulf NP, New England NP, Nowendoc NP, Nymboida NP, Oxley Wild River NP, Single NP, The Basin NR, Timbarra NP, Torrington SCA, Warabah NP, Warra NP, Washpool NP, Watsons Ck NR, Werrikimbe NP.
- *Northern Rivers*: Arakwal NP, Banyabba NR, Billinudgel NR, Border Rangers NP, Broadwater NP, Bundjalung NP, Bungabee NP, Bungawalbin NP, Byrne's Scrub NR, Candle SF, Candole SF, Captains Creek NR, Chambigne NR, Cudgen NR, Fortis Ck NP, Hortons Creek NR, Inner Pocket NR, Koreelah NP, Koukandowie NR, Lawrence Road SCA, Mallanganee NR, Mooball NP, Mt Jerusalem NP, Mt Neville NR, Mt Pikapene NP, Mt Warning NP, Nightcap NP, Pikapene NP, Ramornie NP, Richmond Range NP, Richmond River NR, Sherwood NR, Tallawudjah NR, Tooloom NP, Toonumbar NP, Tuckean NR, Tucki Tucki NR, Tweed Heads Historic Reserve, Tyagarah NR, Ukerebagh NR, Uralba NR, Woodford Island NR, Woodford NR, Wooyung NR, Yabbra NP, Yuraygir NP.
- *Outback NSW*: Ingleba NR, Kinchega NP, Lake Urana NR, Mallee Cliffs NP, Nombinnie NR, Tarawi NR, Tilpilly Station, Weisners Swamp NR, Yathong NR.
- *South Coast and Southern Highlands*: Alpine NP, Bago SF, Bamarang NR, Barnunj SRA, Bellbird NR, Ben Boyd NP, Bermagui NR, Biamanga NP, Bomaderry Creek RP, Bondi Gulf NR, Borang NR, Bournda NP, Brindabella NP, Broulee Is NR, Budawang N P, Budderoo NP, Bundundah NR, Bungonia SRA, Clyde River NP, Comerong Is NR, Conjola NP, Coolangurra SF, Coolumbooka NR, Coolungubra, Coopralamerro NP VIC, Corramy SRA, Croajunolong VIC, Cudmirrah NP, Cullendulla Creek NR, Dananbilla NR, Dandelong NR, Deua NP, Egan Peaks NR, Ellerslie NR, Eurobadalla NP, Fitzoy Falls, Jerawangala NP, Jervis Bay NP, Kooraban NP, Kosciuszko NP, Livingstone NR, Macquarie Pass NP, Meroo NP, Mimosa Rocks NP, Monga NP, Montague Is. NR, Morton NP, Mt Imlay NP, Murramarang NP, Nadgee NR, Narrawallee NR, Nungatta NP, Parma Creek NR, Razorback NR, Red Rocks NP, Rodway NR, Scabby Range NR, SE Forest NP, Seven Mile Beach NP, South East Forest NP, State Forest, Tallaganda NP, Tinderry NR, Triplarina NR, Tumbalong Reserve, Wadbillinga NP, Wallaga Lake NP, Wee Jasper NR, Wereboldera NP, Wingello, Woolamia NR, Woomargama NP, Worrigee NR, Yanununbeyan NR, Yowaka.
- *Sydney and surrounds*: Agnes Banks NR, Bargo SRA, Berowra Valley RP, Blackheath Glen Res., Blue Mountains NP, Botany Bay NP, Bouddi NP, Brisbane Water NP, Burragorang SRA, Castlereagh NR, Cattai NP, Clifton Gardens, Cockle Bay NR, Comelroy SF, Cordeax Dam, Dharawal SRA, Dharug NP, Evans Crown NR, Garawarra SRA, Gardens of Stone NP, Garigal NP, Garrawarra SRA, Georges River NP, Gosford NP, Gulger NR, Head Office, Heathcote NP, Hornsby Council, Illawarra SRA, Jilliby SCA, Kanangra Boyd NP, Ku-ring-gai Chase NP, Lake Cataract Catchment, Lane Cove NP, Leacock RP, Lion Island NR, Llandilo, Long Island NR, Manobalai NR, Marramarra NP, Mile Ridge, MSRA, Mulgoa NR, Munmorah NP, Muogamarra NR, Nattai NP, Newnes State Forest, Parr SCA, Popran NP, Putty SF, Rileys Island, Royal NP, Scheyville NP, Sydney Harbour NP, Thirlmere Lakes NP, Warragamba Special a, Warringah LGA, Werakata NP, Western Sydney Region, Windsor Downs NR, Wirrabalong NP, WNP, Wollemi NP, Wollondilly NR, WSRP, Wyrrabalong NP, Yengo NP, Yerranderie SRA, YRP.

Forestry Plantations Queensland: Analysis was conducted using the logging district information provided by the FPQ. These regions are not congruent with the tourism regions.

Western Australian Department of Environment and Conservation: Analysis was based on regions supplied by DEC. These regions are not congruent with the tourism regions.

Victorian Department of Sustainability and the Environment: Region information was as supplied by DSE. These regions are not congruent with the tourism regions.

Australian Capital Territory Parks Lands and Conservation: The ACT PCL data were analysed using the information provided within the 'district' variable, except that:

- the districts of Gungahlin and Hall were combined
- all districts named NSW and ACT were labelled 'other'
- districts labelled Woden/Canberra or Woden/Weston have been assigned to the Woden region
- districts labelled Woden/Tuggeranong/Stromlo have been assigned to the Weston Creek region.

Statistical areas

In some instances, individual analyses draw on small statistical units for analysis, including statistical region sectors (SRS), statistical subdivision (SSD), and statistical local areas (SLA). Fires were allocated to a statistical local area based on the postcode – either provided or generated from the suburb name – using the ABS (2001a and 2001b). These SLAs then formed the building blocks for the SRS and SSD used in this analysis.

Fundamental differences exist between the statistical units used in this analysis and formulated by the ABS, as follows:

- postal areas used by the ABS and not identical to postcodes used by Australia Post, although the differences are small
- ABS SLAs commonly crosscut postcode boundaries; this impacts not only on SLAs but also the SRS and SSD which are generated from them.

Although there is a variable called statistical local area within some AIRS databases, there were gross inaccuracies in this field, and consequently no attempt was made to use this information in individual analyses. Notably, SLA boundaries and names are subject to change yearly and between each census. Multiple SLA numbers were commonly recorded for the same postcode, obviously covering multiple years, but no information was provided about the SLA definition used in assigning each SLA. Moreover, this variable was not always completed or was subject to other errors. Hence, this variable is less than useful, and could well be removed from the AIRS database structure.

It is noted, that because the tourism regions are defined using ABS (2005) and SLA and SSD were defined using statistical units defined in 2001 (ABS 2001a, & 2001b), there is some discordance between these two classification system. The differences are small, and do not impact markedly on either the total number of fires discussed, or the implications that arise therefrom.

Fire frequency per person

The analysis of fires on a per person basis was conducted using the population of individual postcodes at the 2001 census. It is again highlighted that there is not an exact correspondence between postal areas (ABS) and postcodes (Australia Post) although the differences are small.

Land tenure

Most agencies responsible for fire services in regional and rural areas attend fires on multiple tenures because fire services are coordinated to prevent the escalation of fire events, and because suppressing fires on adjoining tenures reduces the possibility for fires to cross tenure boundaries and affect the tenure for which an agency has responsibility. For example, a national parks and wildlife service will monitor and commonly attend fires near the boundary of a national park, in an attempt to prevent that fire from entering the park, where there may be greater risk of escape and greater difficulties posed for suppression. In many instances, individual agencies record specific information about the tenures on which fires occurred, in some cases distinguishing whether the fire started on or outside of that organisation's tenure, and also where the fire was subsequent controlled and extinguished relative to that tenure. In some cases, the tenure information presented in this report has been summarised from that provided in the database. Details of these modifications are outlined for individual agencies below.

State Forests NSW: Modifications to the tenure categories used in the SFNSW analysis are outlined in Table 20.

Table 20: Tenure category provided, explanation, and tenure category generated for State Forests NSW data

Entry	Tenure	Tenure (generated)
CL	Crown land (leased)	Private property/leasehold (PP)
LG	Local government	Local government (LG)
MR	Military reserve	Other government authority/Interstate (OGA)
NP	National park	National parks (NP)
ON	Other – National Parks control	Other government authority/Interstate (OGA)
OS	Other – State Forests control	Other government authority/Interstate (OGA)
OT	Other public	Other government authority/Interstate (OGA)
PP	Private property	Private property/leasehold (PP)
PV	Pastures protection board (TSR)	Other government authority/Interstate (OGA)
SF	State forests	State forests (SF)
TE	Transmission line easements	Other government authority/Interstate (OGA)
VC	Vacant crown land	Vacant crown land (VL)
WS	Water supply catchment	Other government authority/Interstate (OGA)
.	Missing	Missing (XX)/Unknown

NSW National Parks and Wildlife Service: The relationship between the tenure categories provided and the tenure categories using in this analysis are outlined in Table 21.

Table 21: Tenure category provided and used for NSW National Parks and Wildlife Service data

Code	Tenure	Category	Code
1	?????	U	Unknown
2	ACT	OGA	Other government authority/Interstate
3	BMCC	LG	Local government
4	C	U	Unknown
5	CL	CL	Vacant crown land
6	Council	LG	Local government
7	EA	OGA	Other government authority/Interstate
8	Federal	OGA	Other government authority/Interstate
9	FH	U	Unknown
10	I	U	Unknown
11	LG	LG	Local government
12	LGA	LG	Local government
13	LH	PP	Private property/Leasehold
14	NP/LGA	M	Multiple
15	NP/PP/SF	M	Multiple
16	NPWS	NPWS	National Parks & Wildlife Service
17	NPWS (Commonwealth)	NPWS	National Parks & Wildlife Service
18	NPWS (Ungazetted)	NPWS	National Parks & Wildlife Service

Table 21: Tenure category provided and used for NSW National Parks and Wildlife Service data (continued)

Code	Tenure	Category	Code
19	NPWS/PP	M	Multiple
20	NPWS/SCA	M	Multiple
21	NPWS/SCA/PP	M	Multiple
22	NPWS/SF	M	Multiple
23	NPWS/SF/PP	M	Multiple
24	NPWs	NPWS	National Parks & Wildlife Service
25	NRE	U	Unknown
26	OO	U	Unknown
27	PL	PP	Private property/Leasehold
28	PP	PP	Private property/Leasehold
29	PP/CL	M	Multiple
30	PP/NPWS	M	Multiple
31	PP/NPWS/SF	M	Multiple
32	PP/NPWS/u/k	M	Multiple
33	PP/Other	M	Multiple
34	PP/SF	M	Multiple
35	PP/SF/NPWS	M	Multiple
36	PP/VCL	M	Multiple
37	PP/VCL/NPWS	M	Multiple
38	PTE	U	Unknown
39	QLD	OGA	Other government authority/Interstate
40	QLD npws	OGA	Other government authority/Interstate
41	R	OGA	Other government authority/Interstate
42	RR	OGA	Other government authority/Interstate
43	RTA	OGA	Other government authority/Interstate
44	Rail	OGA	Other government authority/Interstate
45	SCA	OGA	Other government authority/Interstate
46	SF	SF	State forests
47	SF/NPWS	M	Multiple
48	SF/PP	M	Multiple
49	SFL	SF	State forests
50	SRA	OGA	Other government authority/Interstate
51	SW	OGA	Other government authority/Interstate
52	TSR	OGA	Other government authority/Interstate
53	U	U	Unknown
54	U (VicNP)	OGA	Other government authority/Interstate
55	VCL	VL	Vacant crown land
56	VCL & PP	M	Multiple
57	VCL PP	M	Multiple
58	VCL/NPWS/Priv	M	Multiple
59	VCL/PP	M	Multiple
60	VIC	OGA	Other government authority/Interstate
61	VICTORIA	OGA	Other government authority/Interstate
62	VL	VL	Vacant crown land
63	Various	M	Multiple
64	WA	OGA	Other government authority/Interstate
65	WA/NPWS	M	Multiple
66	WLL	U	Unknown
67	npws	NPWS	National Parks & Wildlife Service
68	pp	PP	Private property/Leasehold
69	sf	SF	State forests
70	xxx (missing)	XX	Unknown

Victorian Department of Sustainability and the Environment: The tenure categories used in the DSE analysis were as those provided, except that:

- the two categories, 'Occupied crown land within FPA' and 'Occupied crown land outside FPA' were collapsed to a single category titled 'Occupied crown land'
- the two categories, 'Private property within FPA' and 'Private property land outside FPA' were collapsed to a single category titled 'Private land'.

Forestry Plantations Queensland: Some modification were made to the tenure categories used in the FPQ analysis relative to that provided, as indicated in Table 22.

Table 22: Tenure category provided and used for Forestry Queensland data

Entry	Tenure (provided)	Tenure (generated)
SF	State forest	State forest
Sf	State forest (error)	State forest
NP	National park	National park
LGR	Local govt reserve	Local govt reserve
USL	Unallocated state land	Vacant crown land
VCL	Vacant crown land	Vacant crown land
CFHD	Crown freehold	Other government authority
CWR	Camp & water reserve	Other government authority
FR	Forest reserve	Other government authority
MRD	Main roads	Other government authority
RLWR	Railway Dept reserve	Other government authority
ROAD	Shire roads & stock routes	Other government authority
FREE	Freehold land	Private property/leasehold
GHFL	Grazing homestead perpetual lease (error)	Private property/leasehold
GHPL	Grazing homestead perpetual lease	Private property/leasehold
MISC	Miscellaneous	Other
SL	Special lease	Other
TR	Timber reserve	Other
UNK	Unknown	Unknown

Department of Environment and Conservation (WA): Tenure categories as provided.

Specific location information

Many databases, particularly those database following the AIRS format, document specific information about where a fire started, including the area of origin, the use of the property and the type of complex where the fire occurred. Unfortunately the information available for analysis varied markedly between agencies.

Area of origin

This variable is only relevant to databases using AIRS classification codes. Area of origin refers to the area within a property where the fire originated, being defined by the use at the time of fire ignited. This variable was only in the Victorian CFA analysis.

Victorian Country Fire Authority: The area of origin information supplied by the CFA was summarised using the division outlined in the AIRS database, including 'means of egress', 'assembly, sales areas (groups of people)', 'functional areas', 'storage areas', 'service facilities', 'service, equipment areas', 'structural areas', 'transportation, vehicle areas', and 'other' locations. However, the 'fields', 'lawn, field, open area', 'scrub or bush area, woods, forest', 'on or near railroad right of way, embankment', 'on or near highway, roadway, street, public way, parking lot' and 'vacant structural area with no current use' which are included under the 'other' divisional category in the AIRS database, were delineated as separate categories. A separate category for 'crops, grain, grain handling equipment' was also delineated.

Complex type

This variable is only relevant to databases using AIRS classification codes. According to the AIRS definition a complex is a property complying with all three of the following:

- under one management and ownership
- located within a continuous boundary and
- with multiple uses, that is:
  - a single building with two or more property uses
  - more than one building with the same or different fixed property uses
  - other property uses.

Complex type was used across a number of urban and rural fire services. Where complex types are used, they directly reflect the categories defined within the AIRS database, although in some cases the labels have been abbreviated.

Property use

This variable is only relevant to databases using AIRS classification codes. The type of property use refers to the use of the property at the time the fire occurred. The property use variable used in the analysis is as defined in the AIRS database, with exceptions as outlined in Table 23.

Table 23: AIRS codes and property use category used

AIRS code	Property use
200 to 299	Educational property
300 to 399	Institutional property
400 to 499	Residential property
500 to 599	Shop, store, office
700 to 799	Manufacturing property
800 to 899	Storage property
100 to 109	Public assembly – other
110 to 119	Fixed use amusement
130 to 139	Churches/funeral parlours
140 to 149	Clubs
150 to 159	Libraries/museums/courts
160 to 169	Eating/drinking places
170 to 179	Passenger terminals/stations
180 to 189	Theatres/studios
600 to 609	Industry, utility, defence – unclassified
610 to 619	Nucleonics/energy production
620 to 629	Laboratories
630 to 639	Communication/defence
640 to 649	Utility/energy distribution
900 to 909	Under construction/demolition
910 to 919	Landfill/dump sites
920 to 929	Special structures
940 to 949	Water areas
950 to 959	Railway property
960 to 969	Road/parking
970 to 979	Aircraft areas
980 to 989	Equipment operating areas
1 to 99	Unknown
997	Unknown

Type of property

South Australian Metropolitan Fire Service: The property use variable was not available in the dataset supplied by the SAMFS. However, it was possible to ascertain some information from the 'premises' variable. The following subcategories were generated: aged care, beach/marine/wharf, business, cemetery, child care, community centre, construction/demolition, correctional facilities, dump/rubbish, education, government organisation, hotel, mass transport, medical centre-hospital-ambulance, near non-marine waterway (includes near creek, canal, under bridges), other community facility, other open space, other organisation, recreation complex/sports ground or club, religious facility, reserve-park, residential, road complex, scrub/grassland, vacant or crown land, walkway/bike-path. To a certain extent these judgments were subjective. In several instances fires recorded as occurring 'near a railway line at the back of such-and such school' were coded as 'school' rather than 'mass transport'.

All fires at educational facilities were furthered subdivided by the educational level, into kindergarten/preschool, primary school, high school and tertiary/adult. The tertiary/adult category included universities, TAFE and adult education centres. Where no information was available, the type of school was classified as unknown. Mass transport was subdivided into air, rail and bus. Where sufficient information was available, businesses were subdivided into shopping complex/supermarket, restaurant-fast food outlet, petrol stations, and other. The other category includes industrial businesses, and may include the above categories if no specific information was available.

Timing

The year, week of the year and day of the week a fire occurred were calculated from the date variable list in Table 4. For all but the Northern Territory, fire seasons were based on the financial, rather than calendar, year to ensure that a particular bushfire season was not split between two successive years.

Detection times were subdivided into 24 x 1 hour blocks. There are potentially some inaccuracies between the actual time the fire started and the time the alarm was raised. The length of that delay may vary not only between the fires themselves but also between the type of agency concerned, as the detection of fires is highly dependent on the movement of people in the environment, which in turn is related to the remoteness of the locality and the time the fire occurred. Any time listed as 0 or where data was missing the time was treated an unknown.

Area

The analysis of area burned was based on two types of information: the total area burned, and the frequency of fires that occurred within a particular size range (area category).

Total area burned

The total area burned was used as provided although in some cases it was necessary to sum the area burned across tenure categories, as follows:

State Forests NSW:

Total area burned= 'area – State forests' + 'Loss plant' + 'Area – NPWS' + 'Area – other'

NSW National Parks and Wildlife Service:

Total area burned = 'area (NPWS)' + 'area Other'

NSW Rural Fire Service:

Total area burned = 'private ha' +'local government ha' + 'national park ha' + 'state park ha' + 'forest reserve ha' + 'nature reserve ha' + 'other public ha' + 'defence department ha' + 'other federal ha'

Forestry Plantations Queensland:

Total area burned = 'Burnt OCL (ha)' + 'Burnt freehold (ha)' + 'Area burned (ha)'

Total area categories

The following 'total area burned' categories were defined for all databases where area burned information was available for individual fires:

- Less than 1 ha
- 1–1.99 ha
- 2–2.99ha
- 3–3.99 ha 4–4.99 ha
- 5–9.99 ha
- 10–49 ha
- 50–99 ha
- 100–499 ha

- 500–999 ha
- 1000–1499 ha
- 1500–1900 ha
- 2000–4999 ha
- 5000–9999 ha
- 10,000–49,999 ha
- 50,000–99,999 ha
- Greater than 100,000
- Unknown: Missing, unknown cases.

Vegetation

Many rural fire services and land management agencies provided information about the type of vegetation burned in the fire. This refers to the dominant type of vegetation. The data available for analysis, and in some cases the way that data were summarized, varied somewhat between agencies, as outlined below.

NSW Rural Fire Service: vegetation data provided by the NSWRFS were summarised as outlined in Table 24.

Victorian Department of Sustainability and the Environment: Vegetation codes as provided.

Victorian Country Fire Authority: The vegetation fields used in the analysis were summarised as outlined in Table 25.

Table 24: Vegetation categories provided and vegetation type used for New South Wales Rural Fire Service data.

Vegetation type (provided)	Vegetation type (generated)
Orchards, vineyards	Crops, vineyards, orchards
Crops	Crops, vineyards, orchards
Heathlands (wallum), scrub (southern Australia)	Heathland
Mallee	Mallee
Native eucalypt forest <15m	Native eucalypt forest
Native eucalypt forest 15–35m	Native eucalypt forest
Native eucalypt forest >50m	Native eucalypt forest
Native eucalypt forest 35–50m	Native eucalypt forest
Native grasslands (may be grazed)	Native grassland
Native hummock grasslands, including spinifex, buttongrass	Native grassland
Vegetation type not applicable	Other
Alpine (woodland, herb field)	Other
Native forest, rainforest (generally non-burning)	Other forest
Native trees regenerated after harvesting	Other forest
Native cypress pine forest	Other forest
Grassland, scattered trees	Other grassland
Improved grasslands, grassed areas, grazing	Other grassland
Plantations – native hardwood (blue gum, mountain ash, blackwood)	Plantation – hardwood
Plantations – exotic softwood (pine)	Plantation – softwood
Plantations – native softwood (cypress)	Plantation – softwood
Vegetation type not classified	Unknown
Vegetation type; insufficient info to classify	Unknown
Vegetation type undetermined	Unknown

Table 25: Vegetation categories provided and vegetation categories used for Victorian CFA data

Provided	Used
Alpine (woodland, herb field)	Alpine/Sub-alpine
Sub alpine woodland	Alpine/Sub-alpine
Crops	Crops
Grassland, scattered trees	Grassland, scattered trees
Heathlands (wallum), scrub (southern Australia)	Heathlands/scrub
Improved grasslands, grassed areas, grazing	Improved grasslands
Mallee	Mallee
Native cypress pine forest	Native cypress pine forest
Native eucalypt forest <15m	Native eucalypt forest
Native eucalypt forest >50m	Native eucalypt forest
Native eucalypt forest 15–35m	Native eucalypt forest
Native eucalypt forest 35–50m	Native eucalypt forest
Native forest, rainforest (generally non-burning)	Native forest, rainforest (generally non-burning)
Native grasslands (may be grazed)	Native grassland
Native hummock grasslands, including spinifex, buttongrass	Native grassland
Native trees regenerated after harvesting	Native – regeneration
Orchards, vineyards	Orchards, vineyards
Plantations exotic softwood (Pine)	Plantation – softwood
Plantations native hardwood (Blue gum, Mountain ash, Blackwood)	Plantation – hardwood
Plantations native softwood (Cypress)	Plantation – softwood
Vegetation type not applicable	Vegetation – unknown
Vegetation type not classified	Vegetation – unknown
Vegetation type undetermined	Vegetation – unknown
Vegetation type; insufficient info to classify	Vegetation – unknown
Vegetation type not applicable	Not applicable

Forestry Plantations Queensland: The 37 vegetation species provided by the FPQ were summarised into 6 major categories as follows:

- *Grass.*
- *Hardwoods*: includes the Belah, Blackbutt, Blackdown stringybark, Broad-leaved Red ironbark, Bull oak, Forest red gum, Grey gum, hardwood, hardwoods, Narrow-leaved red ironbark, Scribbly gum, Southern silky oak, Spotted gum, and White Mmahogany categories.
- *Introduced pine*: includes Caribbean pine (var. bahamensi), Caribbean pine (var. caribaea), Caribbean pine (var. hondurens), Elliottii x Hondurensis, F1 hybrid, F2 hybrid, Loblolly pine, Patula pine, Radiata pine, and Slash pine categories.
- *Native pine*: includes Bunya pine, Coast cypress pine, Cypress , Hoop pine, Queensland kauri pine categories.
- *Other*: includes dry sclerophyll, other, rainforest, wallum, wet sclerophyll categories.
- *Unknown*: includes all unknown, missing and or improperly coded data.

South Australia Country Fire Service: vegetation categories used were as supplied except that the following categories – ‘not classified’, ‘undetermined’, ‘insufficient information’, ‘9’, and absent data were classified as ‘unknown’.

Tasmanian Fire Service: vegetation fields supplied by the TFS were summarised in the analysis as indicated in Table 26.

Table 26: Vegetation categories provided and vegetation type used for Tasmanian Fire Service data

Vegetation type (original)	Vegetation (generated)
Crops	Crops, orchards, vineyards
Orchards, vineyards	Crops, orchards, vineyards
Plantations exotic softwood (pine)	Forest – plantation
Plantations native hardwood (blue gum, mountain ash, blackwood)	Forest – plantation
Plantations native softwood (cypress)	Forest – plantation
Alpine (woodland, herb field)	Forest/woodland – native
Grassland, scattered trees	Forest/woodland – native
Heathlands (wallum), scrub (southern Australia)	Forest/woodland – native
Native cypress pine forest	Forest/woodland – native
Native eucalypt forest 15–35m	Forest/woodland – native
Native eucalypt forest 35–50m	Forest/woodland – native
Native eucalypt forest <15m	Forest/woodland – native
Native eucalypt forest >50m	Forest/woodland – native
Native forest, rainforest (generally non burning)	Forest/woodland – native
Native trees regenerated after harvesting	Forest/woodland – native
Sub alpine woodland	Forest/woodland – native
Improved grasslands, grassed areas, grazing	Grasslands – improved
Native grasslands (may be grazed)	Grasslands – native
Native hummock grasslands, including spinifex, buttongrass	Grasslands – native hummock
Mallee	Other
Vegetation type not applicable	Other
Vegetation type not classified	Other
Vegetation type undetermined	Unknown
Vegetation type; insufficient to classify	Unknown

Department of Environment and Conservation (WA): Vegetation categories as provided.

Northern Territory Fire and Rescue Service: The summarised vegetation fields used in the analysis of NTFRS data are provided in Table 27.

Table 27: Vegetation categories provided and the vegetation type used for Northern Territory Fire and Rescue Service data

Vegetation type (provided)	Vegetation (generated)
Crops	Crops
Native grasslands (may be grazed)	Grasslands
Improved grasslands, grassed areas, grazing	Grasslands
Native hummock grasslands, including spinifex, butt	Grasslands
Heathlands (wallum), scrub (southern Australia)	Heathlands, scrub
Mallee	Mallee
Native forest, conifer (e.g. cypress).	Native forest, conifer
Native forest, rainforest (generally non-burning)	Native forest, rainforest
Native sclerophyllous forest >50m, dominated by eucalyptus	Native sclerophyllous forest
Native sclerophyllous forest <15m, dominated by eucalyptus	Native sclerophyllous forest
Native sclerophyllous forest 15–35m, dominated by eucalyptus	Native sclerophyllous forest
Native sclerophyllous forest 35–50m, dominated by eucalyptus	Native sclerophyllous forest
Orchards, vineyards	Orchards and vineyards
Vegetation type not classified above	Other
Vegetation type not applicable	Other
Alpine (woodland, herbfield)	Other
Silvicultural regeneration	Other
Plantations native softwood	Plantation – hardwood
Plantations exotic softwood	Plantation – hardwood
Savannah	Savannah
Plantations native hardwood	Savannah
Vegetation type undetermined	Unknown
Vegetation type; I/I to classify further	Unknown

Fire restrictions/fire bans

For the Queensland Fire and Rescue Service, Metropolitan Fire and Emergency Services Board, Fire and Emergency Services Authority, the data fields used in each analysis were as provided except that:

- fires within the 'fire restrictions not applicable ' and 'fire restrictions not classified above' have in some cases been combined into a single category titles 'not applicable/not classified'
- fires within 'fire restrictions and total bans undetermined' and 'fire restrictions and total bans not reported' have been combined into a single category titled 'undetermined/not reported'.

For the Victorian Country Fire Authority, data fields were as above, except that those where the fire restriction was listed as 'restrictions not classified' were incorporated into the unknown category.

Fire danger index

The fire danger index rating used in Queensland Fire and Rescue Service, Metropolitan Fire and Emergency Services Board, and the Fire and Emergency Services Authority analyses were as reported, except that:

- fires in the 'Not applicable' and 'Not classified above' categories were combined into 'Not applicable/ classified'
- fires in the 'Fire danger undetermined' and 'Fire danger not reported' categories were combined into 'Undetermined/not reported'.

Forestry Plantations Queensland: The numerical values provided were summarised as follows:

- Low: 1 to 5
- Moderate: 6 to 12
- High: 13 to 24
- Very high: 25 to 50
- Extreme: 51 to 200
- Unknown: 0 and greater than 200.

Type of environment

In the ACT Parks Conservation and Lands analysis, a 'type of environment' variable was generated, with individual fires assigned to the urban, urban-fringe, rural, and remote using the name of the reserve on which they occurred.

Urban: Aranda Bushland, Black Mountain, Bruce Ridge, City Parks, CNP (6 units), Cooleman Ridge, CUPPs, CUPPs Mt Stranger, Farrer Ridge, Ginninderra Creek, Gossan Hill, Gungahlin, Gungahlin Grasslands, Gungahlin Hill, Horse Paddocks, Horse Paddocks – Illoura, Horse Paddocks – Kaleen, Horse Paddocks – Mt Taylor, Horse Paddocks – Rose Cottage, Horse Paddocks – Yarralumla, Isaacs Ridge, Jerra. Wetlands, Lyneham Ridge, Mt Ainslie, Mt Majura, Mt Mugga Mugga, Mt Painter, Mt Pleasant, Mt Rogers, Mt Taylor, Mulligans Flat, Oakey Hill, O'Connor Ridge, Oxley Hill, Red Hill, Simpsons Hill, The Pinnacle, Tuggeranong, Tuggeranong Hill, Urban, Wanniassa Hills.

Urban fringe: ACT Forests, ACT Forests – Pierces Creek, ACT Forests – Stromlo, ACT Forests – Melrose, Cotter River, Googong Foreshores, Kowen, Majura Field Firing Range, Molonglo, Molonglo Gorge, MRC, MRC Cotter Reserve, MRC Bullen Range NR, MRC Gigerline NR, MRC Lanyon /Lambrigg CR, MRC

Lower Molonglo NR, MRC Pine Island, MRC Point Hut, MRC Stony Creek NR, MRC Kambah Pool, Rob Roy/Tugg Hill/NSW, Stromlo, Tidbinbilla, Urambi Hills.

Rural: MRC Tharwa, Rural, Rural – Huntley, Rural – Kambah Pool Rd, Rural – Majura, Rural – Melrose, Rural – Oaks Estate.

Remote: MRC Woodstock NR, NNP, NNP Boboyan FMU, NNP Tennent, NNP Cotter FMU 1, NNP Gudgenby, NNP LowCotter, NNP LowCotter FMU 1, NNP Naas FMU, NNP Orroral, NNP Tennent FMU1, NNP Upper Cotter FMU 2, Paddys River, Scabby Nature Reserve.

Unknown: ACT, NSW.

It is emphasised that these can be only a rough approximation, as the rapid expansion of the city has meant that some areas which were largely rural 30 years ago are now classified as urban. Also, the urban fringe grouping may include some reserves or locations that are somewhat distant from urban residential Canberra, but which receive a high flow of recreational users because of their proximity.

Sources of background information

ABS 2005. *Tourism region maps and concordance files, Australia, 2005*. ABS cat. no. 9503.0.55.001. http://www.abs.gov.au/ausstats/abs@.nsf/cat/3235.3.55.001

ABS 2001a. *Australian standard geographical classification*. ABS cat. no. 1216.0. http://www.abs.gov.au/ausstats/abs@.nsf/cat/1216.0

ABS 2001b. *Postal area to statistical local area concordance, Australia, 2001*. ABS cat. no. 1253.0. http://www.abs.gov.au/ausstats/abs@.nsf/cat/1253.0

AFAC 1997. *Australasian Incident Reporting System instruction manual*. Mount Waverley Vic: Australian Fire Authorities Council

Davies C 1997. *Analysis of fire causes on or threatening public land in Victoria 1976/77–1995/96*. Melbourne: Department of Natural Resources and Environment. http://www.dse.vic.gov.au/DSE/nrenfoe.nsf/FID/-4AFB74B010B7E9844A256862001C6C1D?OpenDocument

New South Wales

Contents

The first part of this chapter provides **contextual information** about New South Wales (NSW), including basic information about its climate, geography, land use and population. It also provides an outline of the bushfire regimes, historically important bushfire events, and overview of fire services in NSW. The second part represents an **analysis of data** provided by the NSW Fire Brigade (NSWFB), the NSW Rural Fire Service (NSWRFS), and the NSW National Parks and Wildlife Service. Although both the NSWRFS and NSWFB attend many types of fire, this analysis exclusively refers to vegetation fires, unless otherwise indicated.

For an explanation of the key terms, limitations and methodology refer to the introduction, glossary and methodology chapters.

Introduction

New South Wales is located in southeastern Australia, and is bordered by Queensland to the north, Victoria to the south, the Tasman Sea in the east, and South Australia in the west. It also encloses two territories – Jervis Bay and the Australian Capital Territory – that do not fall within the jurisdiction of the NSW Government.

Geography

The Great Dividing Range (Figure 1), a mountainous range that extends from northern Queensland to central Victoria in eastern Australia, effectively divides NSW into four zones:

- The coastal strip, east of the range, is the most fertile and wettest area of the state. It is further subdivided into the Far South Coast, South Coast and Illawarra, to the south of Sydney; and the Central Coast, North Coast and Northern Rivers regions between Sydney and the Queensland border.
- The Great Dividing Range is not particularly high by global standards, reaching a peak of 2,229 m at Mount Kosciuszko, in the south of the state. Relief on many parts of the central and northern range is comparatively low, but a sharp escarpment that is intersected by numerous steep-sided valleys typically defines the eastern margin. Much of NSW forestry resources and many of the conservation areas lie within this zone. The range itself is divided into the Southern Highlands, Central Tablelands and the New England Region. The Blue Mountains region lies on the eastern edge of the range to the west of Sydney.
- The western margin of the range is largely characterised by gentle slopes that transition westwards into vast agricultural plains that contain only isolated major urban settlements. The regional classifications for this area vary markedly but names applied to this region include the Northwest slopes and plains, Southwest slopes and plains, central west, Riverina and the Murray, but also include Explorer Country among others.
- The far west of the state is arid and sparsely populated, with only a few major settlements, which owe their origin to either transportation, agricultural or mining industries.

Figure 1: Map of New South Wales

Climate

The timing and amount of rainfall received is highly variable across the state. The highest rainfall is experienced on the coastal strip and mountain ranges (Figure 2). The majority of the coastal strip experiences in excess of 1,000 mm of rainfall per year, but the northeast corner of the state locally receives in excess of 2,000 mm per year. Precipitation along the tablelands is commonly in excess of 800 mm per year, but locally reaches in excess of 1,600 mm in parts of the Snowy Mountains and as little as 400 to 500 mm near Cooma. Rainfall decreases inland, with the western quarter of the state receiving less than 300 mm of rain on average (Australian Bureau of Meteorology 2007b).

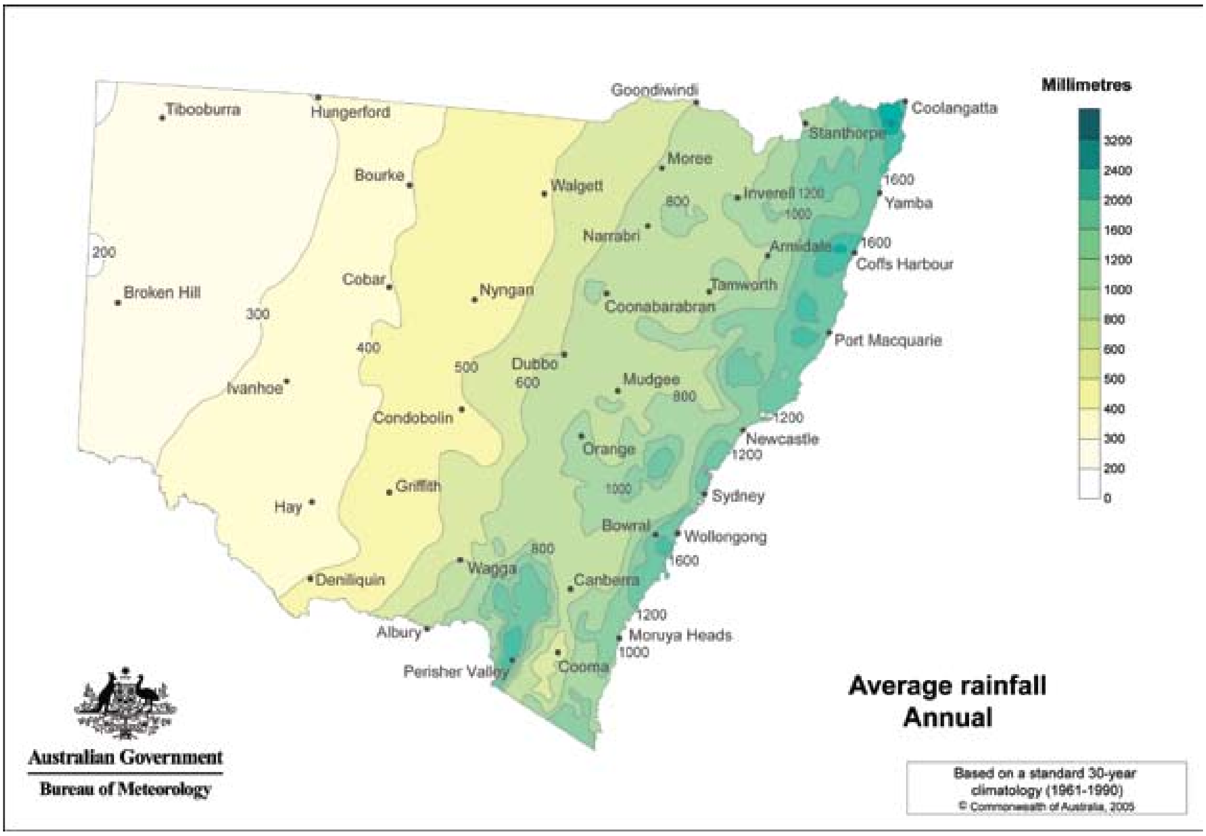
Precipitation in NSW is strongly influenced by:

- the passage of cold fronts across southern Australia, particularly during winter
- moisture-laden air moving onshore from the Tasman Sea
- the southward movement of equatorial low pressure systems during summer.

Hence, there is a shift from wet winters – low rainfall summers in southwestern NSW to wet summers – low winter rainfall in the northeast. In the central region, which incorporates the state capital, Sydney, precipitation is typically more uniformly distributed throughout the year.

Average maximum temperatures increase inland, away from the moderating effects of onshore coastal seas breezes, but also from south to north. Average daily maximum summer temperatures range from 21 to 24°C on the far south coast, to 27 to 30°C on the far north coast, to more than 39°C in the state's far northwest (Australian Bureau of Meteorology 2007a). Snow is typical during winter on the highest parts of the range in southern NSW during winter. Occasion snowfalls may also occur along other parts of the range, but snow rarely persists for more than a couple of days. Hence, the climates range from cool temperate on the far south coast to subtropical in the north coast; and from alpine and sub alpine on the southern mountain ranges to arid desserts in the state's west.

Figure 2: Average annual rainfall for New South Wales



Source: Australian Bureau of Meteorology 2007b

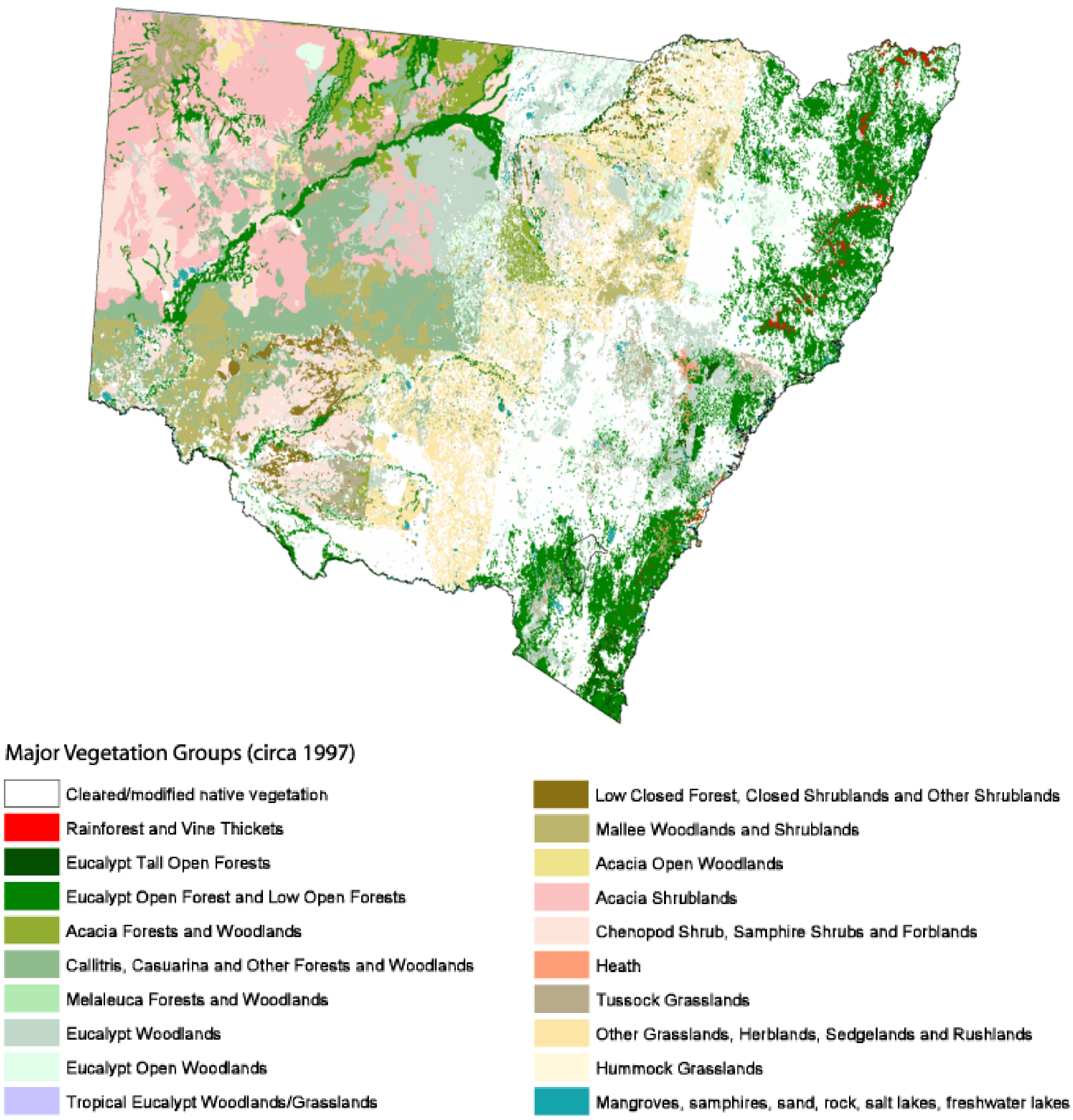
Native vegetation

Vegetation in NSW is highly diverse, reflecting the highly varied nature of climatic and geological environments. Many of NSW vegetation communities also occur in the Australian Capital Territory, Queensland, Victoria and South Australia.

The arid far northwest of the state in dominated by acacia shrublands, and Chenopod shrub (saltbush and bluebush), samphire shrublands (Figure 3). Callistris, casuarina and other forests and woodlands are more abundant in the central far west. Mallee woodlands and shrublands occur in the far southwest of the state. Central and eastern NSW are dominated by grassland composed of native and 'derived' (tree or shrub cover has been removed by clearing or other factors) grasslands.

Eucalypt woodlands are found throughout the state but eucalypt open forests and low open forests principally occur along the coastal plains and ranges, but also in narrower strips bordering major inland river systems. Small patches of temperate and subtropical rainforest principally occur on or at the base of the eastern escarpment, with only isolated patches remaining on the broader coastal plain. Alpine and sub-alpine vegetation in NSW exclusively occurs in the Southern Alps (Snowy Mountains), with the majority of these vegetation types being preserved within the Kosciuszko and Namadgi National Parks (Australia. Department of Environment and Heritage 2001b).

Figure 3: Major vegetation groups (c. 1997)

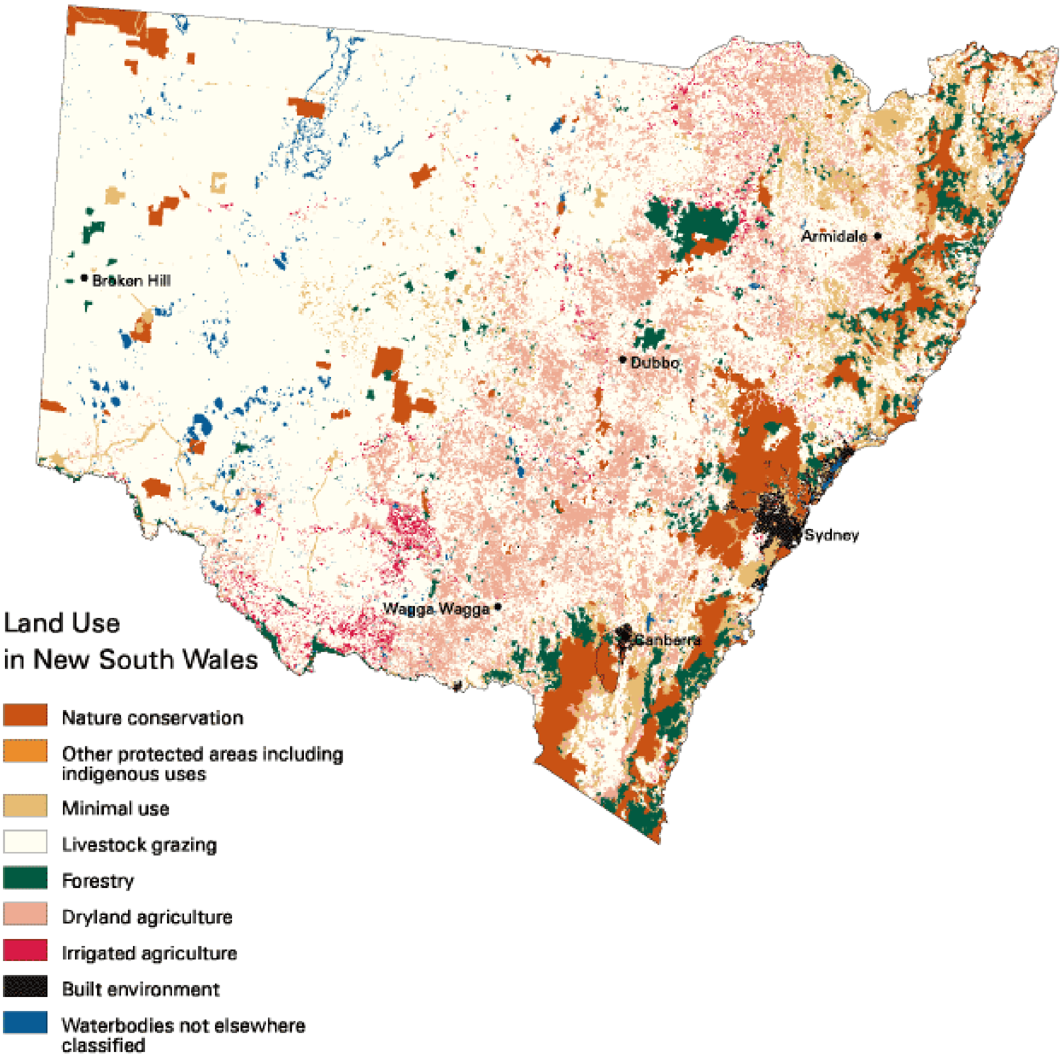


Source: Australia. Department of Environment and Heritage 2001b

Land use

As at 1996–97, nature conservation accounted for seven percent of the total area of NSW; although this is scattered throughout the state, the largest area conserved is located along the range and coastal plains, particular in the Southern Alps, southern highlands, around Sydney and along the northern coast and ranges (Figure 4). A further four percent, used for forestry, has a similar distribution to conservation areas, commonly lying on the margins of those domains. Dryland agriculture accounted for 11 percent of the state and principally occurs within a broad swathe that principally lies on the western slopes and plains but also includes parts of the range. Irrigated agriculture is scattered throughout the state, but principally occurs along the major river systems of the south, including the Murrumbidgee and Murray. Livestock grazing is the principal land use in the west of the state, although this activity is also intermingled with other land uses in the eastern half of the state. Approximately, 68 percent of the state was used for livestock grazing as at 1996–97 (Australia. Department of Environment and Heritage 2001a).

Figure 4: Land use (c. 1996–97)

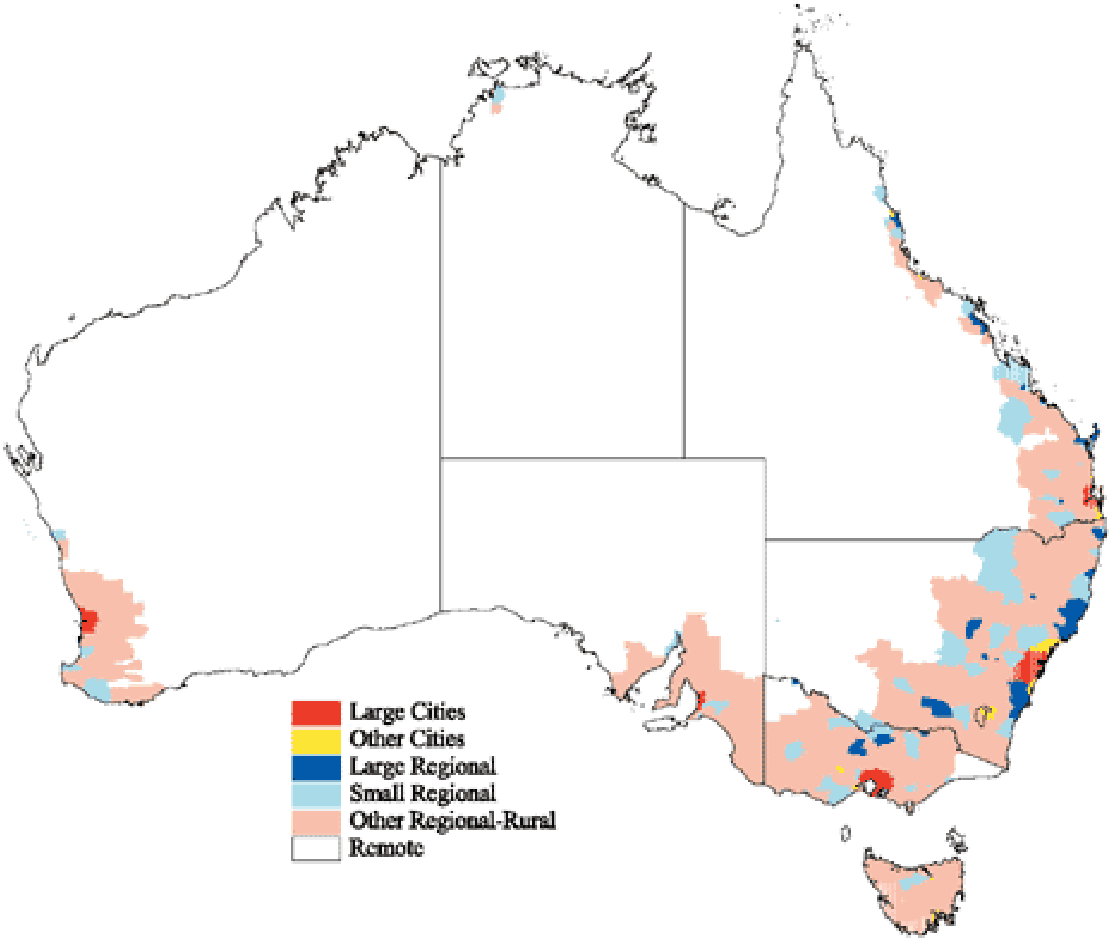


Source: Australia. Department of Environment and Heritage 2001a

Population

As at June 2006, NSW had a population of 6,827,700, accounting for one-third of Australia's total population (ABS 2006) – the overwhelming majority live on the eastern seaboard, principally within large metropolitan and regional centres (Figure 5).

Figure 5: Population distribution of Australia



Source: Australia. Department of Environment and Heritage 2001c

Approximately 63 percent of the NSW population lives in the Sydney region (includes Wyong–Gosford; ABS 2005a). Major cities outside, but within close proximity of, Sydney are Newcastle (on the Central Coast) and Wollongong (in the Illawarra). Larger urban settlements are distributed throughout regional NSW, but principally occur in the eastern third of state. Major regional centres include Albury, on the Victoria border; Broken Hill, in far western NSW); Dubbo, Orange and Bathurst, in the central west; Griffith, Queanbeyan, Leeton, Wagga Wagga and Goulburn, in the Southern Highlands and South West Slopes and Plains; Port Macquarie, Taree, Coffs Harbour, Grafton and Lismore in the North Coast–Northern Rivers region; Tamworth, Armidale and Inverell in the New England and North West region; and Nowra in the South Coast region (Figure 1). The population density, including the density of smaller towns and villages, is highest on the coast, and decreases inland (Figure 5).

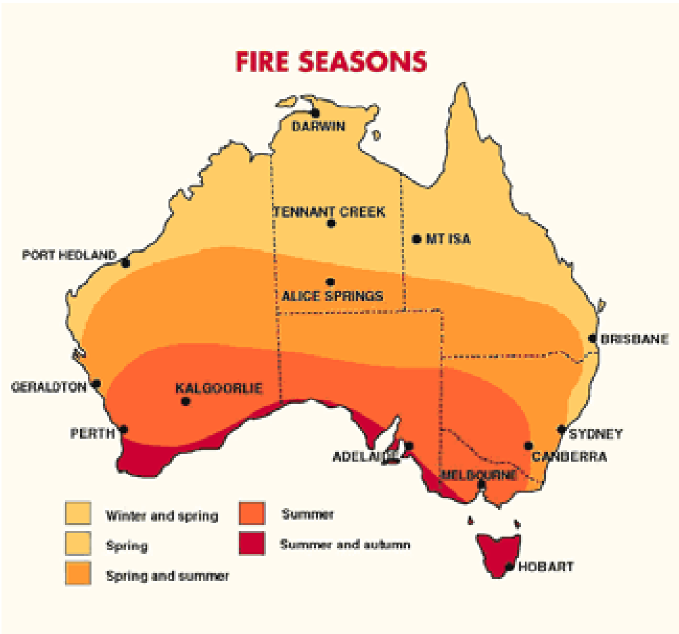
The median age of the state's population is 36.8 years, marginally older than the national average (36.6 years). The lowest median ages occurred in Sydney's southwest, in the local government areas of Campbelltown (31.9 years), Blacktown (32.2 years), Penrith (32.3 years), Liverpool (32.3 years) and Camden (32.5 years). The lowest median ages outside of Sydney were in the northwest local government areas of Bourke (31.4 years) and Brewarrina (31.9 years), followed by Armidale–Dumaresq (33.1 years) and Wagga Wagga (33.5 years; ABS 2005a).

At 30 June 2005, 1.32 million children lived in NSW comprising 19.5 percent of the state's population. Consistent with the median age data, the highest proportion of children in the Sydney region occurred in the city's southwest. The lowest proportion occurred in the inner city. Outside of the Sydney region the highest proportions of children were located in the state's northwest, in the regional centres of Bourke, Brewarrina, Coonamble and Cobar. Low proportions of children occurred in the Richmond–Tweed statistical division (19.3%; 43,500 children), Great Lakes (north coast) (16.3%), Newcastle (16.8%) and Bombala (16.8%) in the snowy region (17.0%; ABS 2005a).

Bushfire regimes

The principal timing of bushfires in NSW varies according to the timing and reliability of rainfall, and hence across the state. The most adverse bushfire period in southwest NSW – including the Snowy Mountains, Riverina, and the Murray regions – occurs during summer, typically occurring at a similar time of the year to bushfire in Victoria, South Australia and parts of Western Australia (Figure 6). For the south coast of NSW, the central and northern tablelands and parts of the northwest, fires principally occur during both spring and summer, whereas for the North Coast and the Northern Rivers regions, fires most typically occur during spring. Bushfire regimes in the latter are more similar to those observed in southern Queensland. Severe bushfires in NSW are commonly linked to periods of drought. Nevertheless, bushfires can occur outside these times due to shorter-scale variations in weather conditions. Also, humans cause fires outside peak bushfire periods and conditions.

Figure 6: Timing of bushfire danger seasons in Australia



Source: Australian Bureau of Meteorology 2007c

Bushfire history

Over the last century NSW has experienced numerous deaths, loss of property and livestock, and large areas burned in bushfires. Major bushfires and bushfire seasons are outlined in Table 1, with selected instances discussed in more detail below. A discussion of the 2001–02 and 2002–03 fires is deferred until the end of the chapter, when data from each fire agency are discussed for these two years, collectively.

1939: 13 to 14 January – On the same day that the fires of Black Friday roared across Victoria, numerous fires broke out in southern NSW, including from Port Hacking to Palm Beach, west in the Blue Mountains, and along the south coast, including at Nowra, Mittagong, Goulburn, Braidwood and Bega. On 13 January 1939 temperatures in Sydney reached 45.3°C. These temperatures followed on the back of heat waves in the previous December that resulted in the deaths of 438 people across southeastern Australia (EMA 2006a). Thirteen people died as a result of the January bushfires in NSW; at least 400 homes were destroyed, with numerous losses of stock and other property (EMA 2006a).

1968: 1 November to 1 December – Fires burned for a month in and around Sydney, the Blue Mountains and the Illawarra region of NSW. The fire claimed the lives of 14 people, the highest recorded in a bushfire in NSW history. It also destroyed 200 buildings of which at least 150 were homes. Over a million hectares was burned (EMA 2006b).

1993–94: December and January – More than 800 fires burned 800,000 ha, affecting coastal areas and nearby ranges in areas from north of Sydney to the Queensland border and south of Sydney to Batemans Bay. These fires were notable as they simultaneously intruded into parts of the Sydney and nearby metropolitan areas, like never before. Approximately one percent of NSW was burned. Despite the severity of the fires, only four people died but 206 houses were destroyed, and 80 other premises were lost. However, in a subsequent report on the fires, ‘A state ablaze: the January 1994 fires’, the NSW Rural Fire Service states ‘Despite the low level of loss, death and injury, there is no room for complacency. Fires similar to those of 1993–94 will occur again (EMA 2006c).

Indeed such seasons have occurred again in NSW, with four adverse seasons in the 10 bushfires seasons between 1993–94 and 2002–03. Collectively these fires resulted in 10 deaths, the loss of 411 houses, with over 2,200,000 ha burned. Almost half of this burned during 2002–03, when there were 151 days of severe fire activity recorded in a single season. The 2001–02 and 2002–03 seasons are discussed in more detail at the end of this chapter, and additional information can be found at NSWRFS (2001, 2003).

Table 1: Fire history of New South Wales

Date	No. of deaths	Area of fire (ha)	Losses	Location(s)
1915 November – 1916 January		Not known		Many districts, Holbrook, Howlong
1926 January – February		Not known	Property losses	Junee, Canberra, Albury, Rydal, Wagga Wagga
1926 October – 1927 December	8	>2,000,000		North Coast and Newcastle district, Canberra, Albury, Dubbo, Griffith
1938 December – 1939 January	13	73,000	Many houses, pine plantations	Dubbo, Lugarno, Snowy Mountains, Canberra
1944 November – December	2		150 houses, churches	Blue Mountains, Lochinvar
1951 November – 1952 January	11	>4,000,000		Worst affected district around Wagga Wagga and Pilliga in the north-west
1957 December – 1958	5	>2,000,000	158 houses, many businesses, shops, schools, churches and a hospital	Blue Mountains, Leura
1964–1965 March	5	530,000	Houses, farms, forests	Snowy Mountains, Southern Tablelands, Nowra, Sydney
1968 September – 1969 January	14	>2,000,000	161 buildings (80 houses)	South Coast (Sept.), much of the coastal and nearby range areas of the state
1969–70	1	280,000		Roto and Riverina areas
1972 December – 1973 January		300,000		Kosciouszko National Park, Eden, Queanbeyan, Burrinjuck Dam
1974–75	6	4,500,000	50,000 stock, 10,170 km fencing	Bourke to Balranald, Cobar Shire, Moolah–Corinya–most of the Western Division
1976–77		74,000	3 houses	Hornsby, Blue Mountains
1977–78	3	54,000	49 buildings	Blue Mountains
1978–79		>50,000	5 houses, heavy stock loss	Southern Highlands, south-west slopes
1979–80	13	>1,000,000	14 houses	Mudgee, Warringah and Sutherland Shires, majority of council areas, Goulburn and South Coast
1982–83	3	60,000	$12 million of pines	Blue Mountains, Sutherland and southern NSW
1984–85	5	3,500,000	40,000 stock, $40 million damage	Western Division
1986		10,000		Mount Kaputar National Park
1987–88	4	180,000		Bethungra, Warurillah–Yanco, southeastern part of Kosciouszko National Park, Sutherland, Penrith, Wellington
1990–91		>280,000	8 houses, 176,000 sheep, 200 cattle, hundreds of km of fencing	Local government shires of Hay, Murrumbidgee, Carrathool; Hornsby, Ku-ring-gai, Cessnock, Hawkesbury, Warringah, Wollondilly, Gosford, Wyong
1991–92	2	30 fires	14 houses	Baulkham Hills, Gosford City, Wyong Shire, Lake Macquarie
1993 December – 1994 January	4	>800,000 (>800 fires)	206 houses destroyed, 80 other premises destroyed	North Coast, Hunter, South Coast, Blue Mountains, Baulkham Hills, Sutherland, most of Royal National Park, Blue Mountains, Warringah–Pittwater
1997 November – 1998 January	3	>500,000 (250 fires)	10 houses destroyed	Hunter, Blue Mountains, Shoalhaven, Menai, Coonabarabran, Padstow Heights, South Windsor – Bligh Park
2001 December – 2002 January		744,000 (454 fires)	109 houses destroyed, 6,000 head of livestock	Across 44 local government areas in the Greater Sydney, Hunter, North Coast, mid north coast, Northern Tablelands, Central Tablelands areas
2002 July – 2003 February	3	1,464,000 (459 fires)	86 houses destroyed, 3,400 stock, 151 days of severe fire activity	81 local government areas in Greater Sydney, Hunter, North Coast, Northern Tablelands, Northern Rivers, northwest slopes, northwest plains, Central Tablelands, Southern Tablelands, Illawarra, South Coast

Source: Ellis, Kanowski & Whelan 2004

Fire services

Four major agencies provide fire services in NSW; the NSW Rural Fire Service, the NSW Fire Brigades, the National Parks and Wildlife Service, and State Forests of NSW.

The **New South Wales Rural Fire Service** (NSWRFS) incorporates 2,094 brigades and about 69,300 volunteers that provide fire services for 90 percent of the state, attending structural firefighting services in more than 1,200 towns and villages. During serious bushfire situations that are declared under section 44 of the *Rural Fires Act 1997*, the Commissioner of the Rural Fire Service has responsibility to ensure coordination of all agencies in NSW. For more information about the NSWRFS see <http://www.bushfire.nsw.gov.au>.

The **New South Wales Fire Brigades** (NSWFB) is the NSW government agency responsible for managing fire emergencies in major cities and towns across metropolitan and regional NSW. The NSWFB provides coverage for 90 percent of the state's population. As of 2005–06, the NSWFB had 338 fire stations, 6,546 firefighters and 5,500 community fire unit members. More information about the NSWFB can be found at <http://fire.nsw.gov.au>.

The **National Parks and Wildlife Service** falls under the umbrella of the NSW Department of Environment and Conservation and Climate Change (DECCC). Under the *Rural Fires Act 1997*, the National Parks and Wildlife Service is responsible for managing fires on all lands under its control, including detecting and suppressing fires and implementing risk prevention programs to protect life and property from fires. DECCC also helps suppress fires on adjacent lands, as may be required under plans prepared under the *Rural Fires Act 1997*. The location of National Parks and Wildlife's jurisdiction in NSW is broadly consistent with the areas defined as 'nature conservation' in Figure 4. More information about the NSW NPWS can be found at http://www.nationalparks.nsw.gov.au.

State Forests of New South Wales (SFNSW) has statutory responsibly 'to protect life and property from wildfire; to minimise the spread of wildfire from state forests and other land managed by State Forests; and to protect state forests and their environmental values from the damaging effects of wildfire'. SFNSW jurisdiction is broadly consistent with the areas defined as 'forestry' in Figure 4. More information about SFNSW can be found at http://www.dpi.nsw.gov/forests/

It should be noted that although individual agencies principally attend to fires within their jurisdiction, this is not exclusively the case. Fire agencies may attend fires on lands outside their jurisdiction when:

- there is potential for fires on neighbouring properties to pose a danger to the resources that that organisation is entrusted to protect
- large fire campaigns require the pooling of resources
- another fire agency seeks assistance.

One of the implications of these arrangements is that more than one agency may attend the same fire, resulting in a duplication of fire details across individual databases.

New South Wales Rural Fire Service analysis

Background about the NSWRFS dataset and its analysis

Important information about the NSWRFS dataset and the methodology employed in the analysis it is outlined below:

- Data was sourced from the NSWRFS.
- The data provided included vegetation (wildfires) fires only. Hence, all references to fire in this analysis refer exclusively to vegetation fires unless otherwise indicated.

- The dataset included fires from 1999–2000 and 2003–04.
- The database used Australian Incident Reporting System (AIRS) variables and codes.
- The cause of the fire was based on the ignition factor variable provided.
- Deliberate vegetation fires refer to all vegetation fires classified as incendiary (AIRS ignition factor code = 110 or 120) or suspicious (AIRS ignition factor code = 210 or 220).
- Natural fires refer to all fires where the ignition factor codes were 800 to 890, that is, fires that resulted from any natural condition or event. The breakdown of NSWRFS fires was; high wind 18 percent, high water including floods 0.1 percent, lightning 74 percent, and fires resulting from any other natural condition eight percent.
- Information about the form of heat of ignition was not included within the supplied database.
- Smoking-related fires included all fires where: ignition factor = abandoned or discarded materials (Ignition Factor code = 310).
- All fires attributed to children and discussed in the text were classified accidental in origin. This may only be a small subset of fires started by children, as malicious fires started by children are incorporated in the incendiary or suspicious categories and cannot be identified. Information about the age of the child was supplied.
- The regions used in the NSWRFS analysis were based on Australian Bureau of Statistics (ABS 2005b) tourism regions. The ABS defines tourism region based on smaller statistical areas that potentially crosscut suburbs and postcodes. In this study, assignation was based on the highest levels of concordance between individual suburbs and tourism regions. Hence, there is not an exact correspondence between tourism regions used in this analysis and ABS tourism regions.
- The dataset included information about the area burned.
- No information was available about fire restrictions or fire danger index.

For more detail about these methodologies see the methodology chapter.

Overview

Fires the NSWRFS attended can be summarised as:

- The NSWRFS recorded 23,664 vegetation fires across regional NSW between 1999–2000 and 2003–04. The lowest number (n=722) was recorded for 1999–2000 but it is uncertain if these data were complete given the substantially higher numbers recorded in subsequent seasons (Figure 7). Excluding 1999–2000 the lowest number of fires were observed during 2000–01 (n=3,289). The highest number was recorded during 2002–03 (n=7,349), although a large number of fires also occurred in 2001–02 (n=6,696). Both were particularly adverse seasons in NSW.
- The NSWRFS attends many different types of vegetation fire incidents from small grass fires through to large bushfires. However, almost 90 percent of all incidents attended were grassfires. The number of forest fires was exceptionally small, accounting for 2.3 percent of all fires attended. This is broadly similar to the number that occurred in heathland (1.9%). The proportion of deliberate fires was broadly similar across most vegetation types, although comparatively fewer fires in crops, vineyards and orchards resulted from this causes, and a high proportion of fires in hardwood plantations were deliberately lit.
- Deliberate causes were attributed to 18.5 percent of all fires (2.6% incendiary, 15.9% suspicious), representing 38 percent of known causes of fires attended. Fires of natural origin comprised 8.8 percent of all fires attended, comprising 18 percent of fires of known cause.

- A total of 1,173,114 ha were burned in fires the NSWRFS attended from 1999–2000 to 2003–04; 16 percent of this was burned by deliberate fires. These fires were principally identified as suspicious, as opposed to incendiary, in origin. A large proportion of all area burned by deliberate fires occurred in 2001–02. Natural fires were a critical factor in the large areas burned in both 2001–02 and 2002–03.

Cause

The cause of just over half of NSWRFS-attended vegetation fires from 1999–2000 to 2003–04 was listed as unknown. Non-deliberate causes accounted for 29.7 percent of all fires, and hence the majority of cases where causal attributions were made (Figure 8); accidental and natural causes were responsible for 14 and nine percent of fires, respectively. Incendiary causes were responsible in 2.6 percent of cases, but suspicious fires accounted for a further 15.9 percent of cases. Hence, deliberate causes – incendiary and suspicious fires combined – accounted for 38 percent of cases where causal attributions were made. This value is consistent with that observed in other jurisdictions.

The percentage of deliberate fires varied markedly between seasons, accounting for approximately 25 to 30 percent of fires in the 1999–2000 and 2000–2001 seasons, but 15 to 20 percent of fires from 2001–02 to 2003–04, when overall numbers were higher. Although there is an antipathetic relationship between the proportion of suspicious and unknown lightings, deliberate causes comprised just 35 to 37 percent of known causes from 2001–02 to 2003–04 as compared to 45 to 50 percent during the previous two years (Figure 9).

This value is somewhat lower than the value of roughly 60 percent deliberate recorded for fires that are subject to detailed fire investigation (AIC 2005). There are potentially many contributors to these disparities, as outlined below. For example, only a small number of fires are referred for investigation; deliberate causes may be over-represented within this subset as suspicious fires may be more likely to be referred for investigation. On the other hand, deliberate causes are likely to account for a higher proportion of 'unknown' causes as likely and obvious causes, including accidental and natural ignitions have, in many cases, already been eliminated as likely causes.

Specific ignition factors

Ignition factor: The factors responsible for ignition can be summarised into nine major categories based on the divisional category headings outlined with the AIRS codebook (Figure 10), except that incendiary and suspicious fires are combined into a deliberate category. These broadly resemble those used in Figure 8 but provide further discrimination with regard to the principle cause of non-deliberate fires; no further information is available about the ignition factor responsible for deliberate fires.

Overall, mechanical failure and malfunction, factors relating to design, construction, and installation and operational deficiencies accounted for a small proportion of fires the NSWRFS attended (Figure 10). 'Other' ignition factors – primarily fires resulting from rekindling of previous fires, separate or attached exposure, vehicle fires and other unclassified ignition factors – were collectively responsible for 9.4 percent of fires. Vehicle fires accounted for 8.8 percent of all non-deliberate fires, but were less numerous than fires resulting from rekindling (Figure 11).

Misuse of heat of ignition was responsible for 7.5 percent of all fires (Figure 10). All such fires were classified as accidental herein (for example, in Figure 8). These primarily arose from the inadequate control of an open fire, being singly the largest cause of accidental fires, and accounting for 17.6 percent of all non-deliberate fires (n=1,238; Figure 11). The misuse of heat of ignition category also included fires started by children and fires attributed to abandoned or discarded materials (e.g. cigarettes; see methodology chapter).

Fires started by children: Children up to 16 years of age were identified as being responsible for 96 non-deliberate fires (0.4% of all fires) the NSWRFS attended between 1999–2000 and 2003–04. Approximately 60 percent of those fires these were started by six to 12 year olds, with another one-third being attributed to 13 to 16 year olds (Figure 12). Only seven percent were started by children five years and younger.

Although the number of fires started by children in any one year was low, there was a strong correlation ($r=.97$; $p<.001$) between the number of non-deliberate child fires and the total number of fires within any one season. Hence, the highest numbers of non-deliberate child fires were recorded in 2001–02 and 2002–03 (Figure 13). In both instances, six to 12 year olds were the most frequent age group identified. This differs from the typical trend where the 13 to 16 year old group was the most commonly identified group.

Smoking-related fires: Approximately 0.7 percent (n=169) of fires the NSWRFS attended from 1999–2000 and 2003–04 were attributed to abandoned or discarded materials within the ignition factor variable. This figure is unlikely to be an accurate reflection of the total number of fires that were classified as smoking-related, as not all fires classified as smoking-related within the 'form of heat of ignition' variable within the AIRS database are classified as resulting from abandoned or discarded materials within the ignition factor variable (see methodology chapter).

The number of fires resulting from abandoned or discarded materials steadily increased during the observation period, with variations being largely independent of the fluctuations in total fire numbers (Figure 14). In 2003–04, fires of this cause contributed to 1.3 percent of fires the NSWRFS attended. Even this highest value was markedly lower than the rates the NSWFB recorded, but lies within the range reported for other rural fire agencies.

Vehicle fires

There are several ways that vehicles can cause a vegetation fire; for example, accidents involving a motor vehicle, the spillage of fuel, and exhaust systems. However, many fires in vegetation also arise when abandoned or stolen vehicles are set alight in vegetated areas. This may be because the vehicles have been left on a road verge or because heavily vegetated areas afford a lower risk of the offender being observed. While neither situation reflects an active attempt to set vegetation alight, the latter is genuinely an act of arson.

It is difficult to accurately document the number of vegetation fires that indirectly resulted from a motor vehicle fire and, with the exception of several land management agencies, fires resulting from the torching of abandoned or stolen motor vehicles have not been included within this report. Notably, agencies that use the AIRS database structure would principally document such fires as 'mobile property type fire' (type of incident code) as the vegetation fire is regarded secondary to the original fire. Information about mobile property-type fires was only available for four agencies and the inclusion of this data would potentially influenced the analysis for some agencies but not others. Moreover, although some information was provided about the type of location where the fire occurred ('Complex' or 'Property use') and the area burned, there is commonly a lack of information about whether the vehicle fire subsequently spread or had the potential to spread to neighbouring vegetated areas. For example, there is little information (without using more complex geospatial information) about whether a fire at a road complex occurred along a highway surrounded by thick bushland, or at the end of a street surrounded by pavement. Hence, if we only consider mobile property fires that occurred in parks, forests and reserves, we are likely to markedly underestimate the total number of mobile property fires that did or had the potential to result in a vegetation fire. The data included for some land management agencies highlights the ever-present danger that such practices can pose to natural resources (forestry and conservation). The brief discussion below also shows the potential enormity of the problem in urban and semi-urban environments.

The NSWFB attended almost 29,000 mobile property type fires from 1997–98 to 2001–02; it attended 55,730 wildfires during the same period. Of the 29,000 mobile property fires, 55.7 percent of them were either incendiary or suspicious in nature (Table 2). Approximately 62 percent of deliberate vehicle fires occurred at road complexes but the extent of vegetation in the area was unspecified in the database. A further nine percent of deliberate fires (approximately 1,500 fires in five years) occurred in parks, forests and reserves and 11 percent of deliberate fires occurred on unused property or on Crown land. A higher proportion of vehicle fires that occurred in ‘parks, forests, reserves’ or on ‘unused property/Crown land’ were deliberate when compared with mobile property fires along road complexes. To put this in perspective, if all incendiary and suspicious mobile type property fires that occurred in ‘parks, forests, reserves’ and ‘on unused property/Crown land’ were included within the wildfire analysis, the total number of incendiary and suspicious bushfires the NSWFB reported in any given season would have increased by 12 to 24 percent. This figure does not incorporate vehicles that were torched in vegetated areas, along roadways, etc. While it is recognised that only some of the deliberate vehicle fires subsequently spread to neighbouring vegetation, the potential problems posed by this practice cannot be underestimated.

Table 2: Mobile property type fires for selected agencies

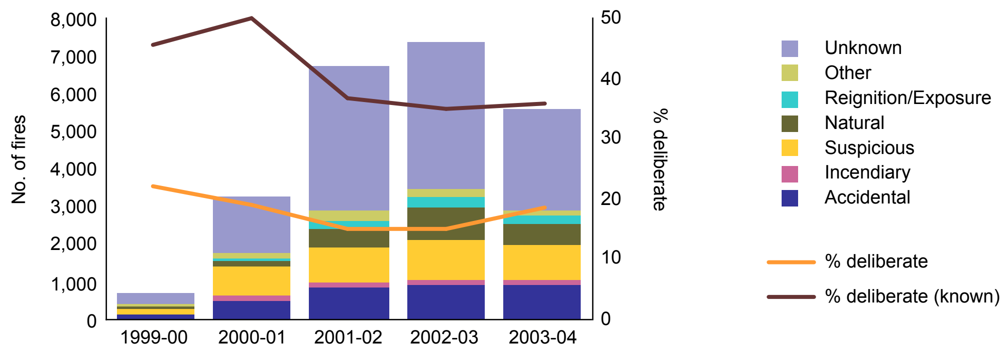
	Total no. mobile property-type fires attended 1997–98 to 2001–02[a]	% of these incendiary or suspicious	% of all (incendiary/ suspicious) vehicle fires that occurred in parks, forests, reserves	% of all (incendiary/ suspicious) vehicle fires that occurred in road complexes	% of all (incendiary/ suspicious) vehicle fires that occurred on unused property/Crown land
NSWFB	28,692	55.7	7.0 (9.2)	65.0 (61.7)	7.9 (11.1)
MFB[b]	7,960	44.4	5.6 (11.9)	71.0 (63.2)	2.9 (6.0)
QFRS[b]	8,803	10.7	3.4 (7.3)	57.7 (45.7)	8.5 (17.7)
FESA[b]	2,252	55.1	3.7 (5.5)	56.2 (47.7)	13.0 (20.0)

a: figures are incomplete for FESA and QFRS due to the gradual implementation of the AIRS database reporting scheme

b: MFB = Metropolitan Fire and Emergency Services Board (Melbourne, Victoria); QFRS = Queensland Fire and Rescue Service; FESA = Fire and Emergency Services Authority (Western Australia)

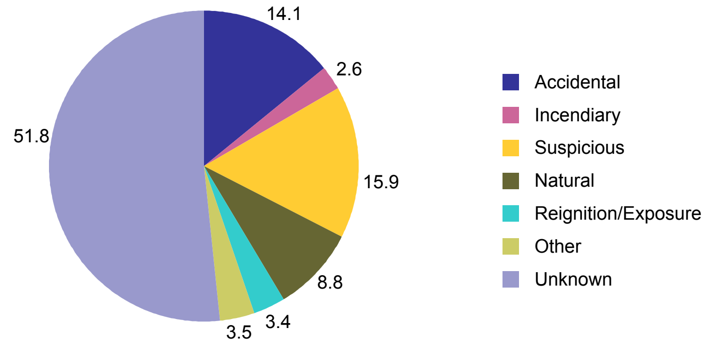
Source: NSWFB 1997–98 to 2001–02; MFB 1997–98 to 2001–02; QFRS 1997–98 to 2001–02; FESA 1997–98 to 2001–02

Figure 7: Cause of fires, by year



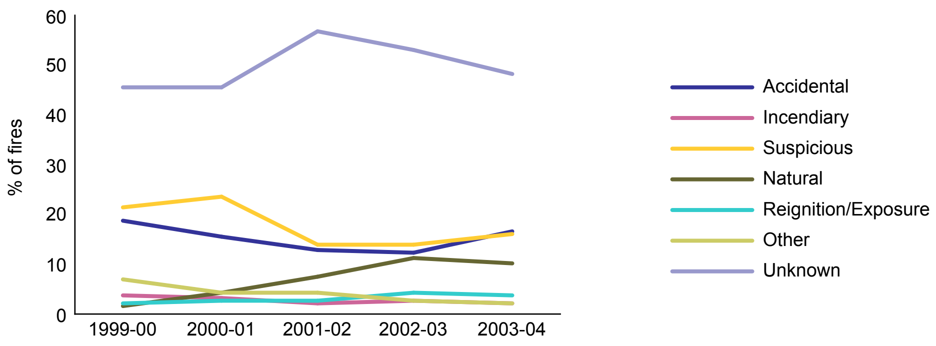
Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Figure 8: Cause of fires (percent)



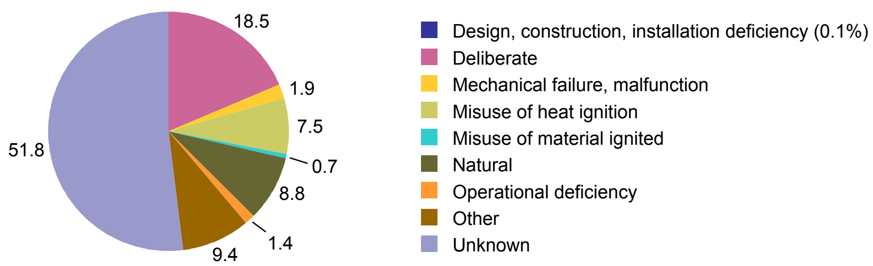
Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Figure 9: Cause, by year (percent)



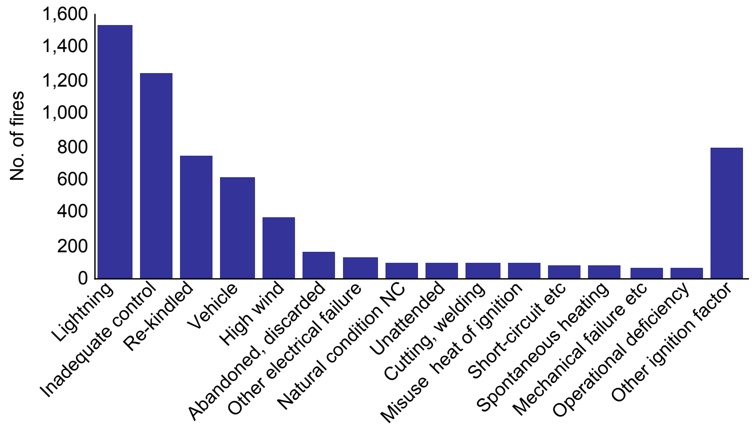
Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Figure 10: Ignition factor category (percent)



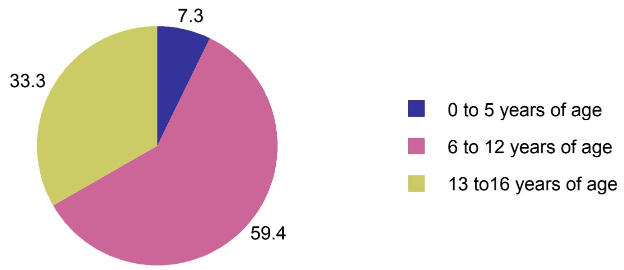
Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Figure 11: Non-deliberate fires, by ignition factor (number)



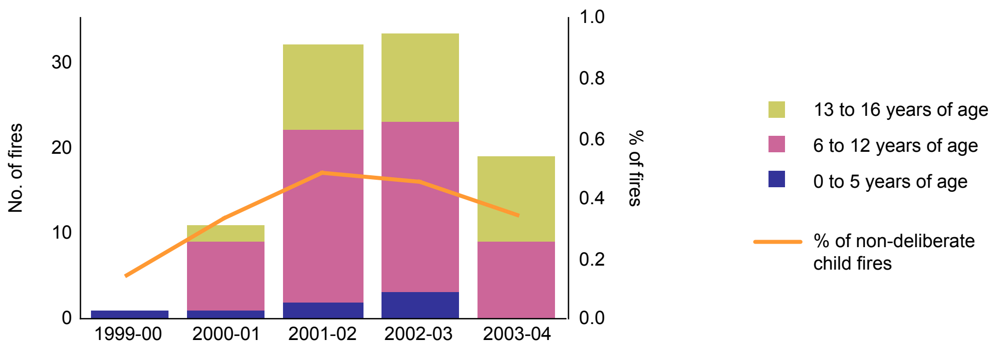
Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Figure 12: Non-deliberate child fires, by age (percent)



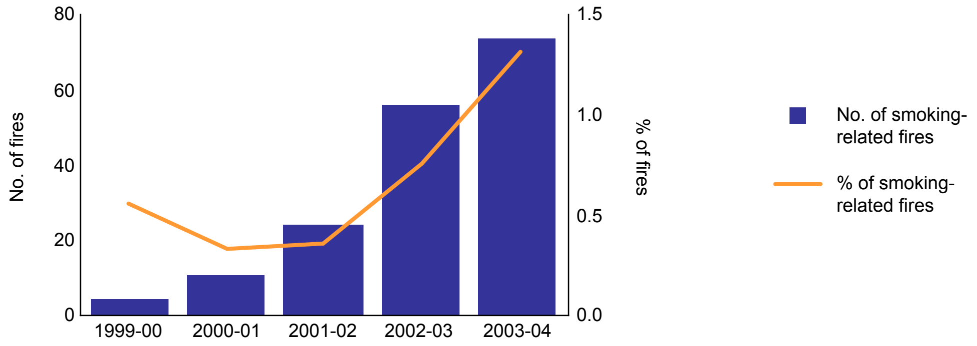
Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Figure 13: Non-deliberate child fires, by age and year



Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Figure 14: Smoking-related fires, by year



Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Location

The location of fires the NSWRFS attended is examined in terms of the region in which they occurred, the concentration of fires within individual suburbs, and the tenure of land.

Region

Between one-fifth and one-quarter of **all fires** the NSWRFS attended occurred in the Sydney region (Table 3; Figures 15 and 16).

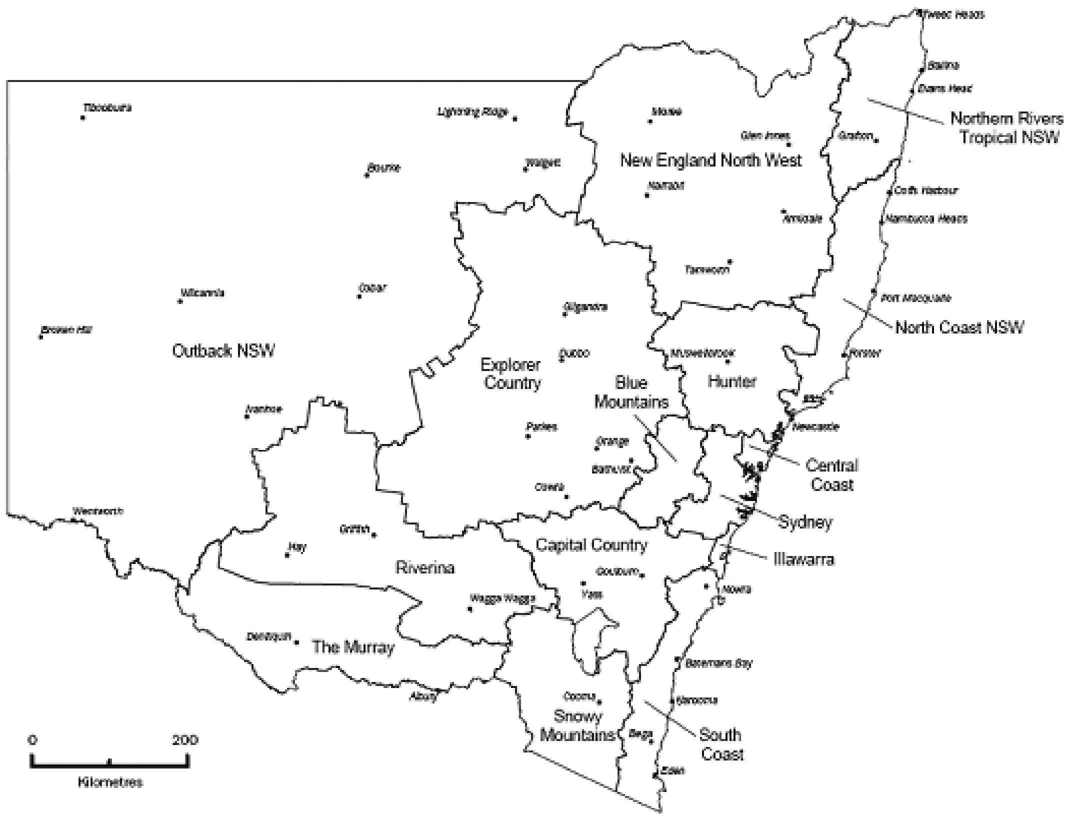
Table 3: Number of suburbs recording fire frequencies (all causes) within the indicated range

	Sydney	North Coast	Explorer Country	Hunter	Nthn Rivers	New Engl. NW	South Coast	Central Coast	Capital Country	Riverina	The Murray	Snowy Mtns	Illawarra	Blue Mtns	Outback
All fires	5,241	4,078	2,104	2,052	1,741	1,661	1,648	924	922	874	564	507	457	436	425
No. of suburbs															
Total	315	276	192	227	243	123	125	109	88	83	56	52	53	62	30
≥150	1	1	1												
100–149	7	2	2			1	1			1					
50–99	21	10	2	5	2	7	2	2	3	1		2	1		2
25–49	38	39	12	15	8	11	16	5	5	7	3	2	5	4	4
<25	248	224	175	207	233	104	106	102	80	74	53	48	47	58	24
Percentage of fires in region within suburbs with:															
≥150	4	6	9												
100–149	16	6	12			8	7			16					
50–99	29	17	9	18	6	27	8	12	18	8		21	21		35
25–49	25	31	21	24	16	24	32	18	17	27	20	14	37	33	30
<25	27	40	48	58	78	41	53	70	65	49	80	66	42	67	35

Source: NSWRFS 1999–2000 to 2003–04 [computer file]

A further 18 percent occurred on the North Coast region, and seven to nine percent occurred each in the Explorer Country, Hunter, Northern Rivers, New England–North West, and in the South Coast regions (Table 3; Figure 16). The principal causes of vegetation fires varied markedly between regions, although in all instances considerable uncertainty arose from the high levels of unknown attributions.

Figure 15: Tourism regions of New South Wales



Source: ABS 2005b

The number of **deliberate fires** was strongly correlated with the total number of fires that occurred in each region (r=.95). Nevertheless, there was considerable variation in the percentage of fires that resulted from deliberate causes. The highest percentage of deliberate fires occurred in the Illawarra (40%), Blue Mountains (30%), South Coast (28%), Central Coast (26%) and Hunter (22%) regions. Deliberate fires only accounted for 18 percent of fires in the Sydney region. However, the cause of approximately two-thirds of fires in the Sydney region was unknown.

If we exclude unknown causes (that is, only those cases where causal attributions were made) it is evident that the highest rates of deliberate fires occurred in those regions with close proximity to Sydney; notably, deliberate fires constituted 45 to 62 percent of 'known' fire causes in the Illawarra, Central Coast, Sydney, Blue Mountains, South Coast and Hunter regions. Although most regional areas were characterised by a lower proportion of deliberate fires, high values were recorded for both the North Coast (45%) and the Outback (39%).

Natural fires were an important known cause of fires in the Explorer Country (25%), Snowy Mountains (21%), Capital Country (20%), New England–North West (18%) and the Murray regions (17%; Figure 17). In contrast, only three to four percent of fires in the Sydney, Central Coast and North Coast regions resulted from natural ignition factors.

The greatest numbers of **non-deliberate child fires** occurred in the Sydney, Explorer Country, Outback and North Coast regions, although the actual numbers did not exceed 20 in any one region, and therefore likely grossly underestimate the role of children in starting fires in all regions (Figure 18). The percentage of fires started by children in the Outback region (2.5%) was substantially higher than the regional average (0.5%).

The greatest number of **smoking-related fires** occurred in the North Coast and Sydney regions (Figure 19), with the number of smoking-related fires being broadly correlated with total fire number in each region (r=.88). The highest proportion of fires smoking-related fires occurred in the Capital Country, Snowy Mountains and Riverina regions. However, smoking-related materials contributed to less than two percent of fires in all regions.

Suburb

There is a predictable statistical relationship between the number of suburbs that recorded a fire and the total number of fires that occurred within that region (r=.92; p<.001), with fires being recorded in more suburbs in those regions that experienced the largest number of fires. This relationship also holds for deliberate fires, but the strength of the relationship is weaker (r=.77; p<.001). This may indicate that deliberate fires tended to be more concentrated; but caution is required in such an interpretation, as the generally low and sometimes variable levels of causal attribution will affect the results for deliberate fires.

Generally, suburbs recording the greatest number of fires (all causes) tended to occur in those regions that documented the greatest number of fires (Table 3; Figure 20). For example, the Sydney, North Coast and Explorer Country regions were the only ones to contain a suburb that experienced 150 fire or more in a five-year period. Suburbs recording 100 to 149 fires occurred in six regions (Figure 20); these included the Sydney, North Coast and Explorer Country regions, as well as one suburb each in the New England–North West, South Coast and Riverina regions. However, in comparison to the NSWFB, individual locations recording high numbers of fires accounted for a comparatively small proportion of all fires within that region. This reflects two separate factors. First, the NSWRFS data were examined at suburb level, whereas the NSWFB analysis was conducted at a postcode level. Second, fires the NSWRFS attended were more broadly dispersed; a natural reflection of the large geographical area that falls within its jurisdiction.

The **concentration of fires** within specific areas varied markedly between regions. These are discussed below.

Sydney: Eight suburbs in the Sydney region experienced more than 100 fires in total (all causes) in five years (Table 3), with four of those occurring in the Campbelltown statistical local area (SLA), three in the Penrith SLA, and one in the Hawkesbury SLA. Fifty or more deliberate fires were documented in one suburb. Five suburbs recorded approximately 25 deliberate fires in five years. Based on the available data, suburbs in the Sydney region that experienced 50 or more, 25 to 49, and 10 to 24 deliberate fires in five years accounted for six percent, 20 percent and 54 percent of all deliberate fires recorded by the NSWRFS in the Sydney region, respectively (Figure 21).

However, the generally low level of causal attribution documented for the Sydney region heavily influences the statistics for deliberate fires. On average only 19 percent of fires in suburbs recording 50 or mores fires in five years were identified as deliberate, but deliberate origins accounted for two-thirds of known causes in those suburbs, and up to 90 percent of known causes in those suburbs recording the highest numbers of fires overall. The highest rates actually recorded for deliberate fires (45%) occurred for two suburbs in the Campbelltown and Liverpool SLAs.

South Coast: One suburb in the Shoalhaven (Part A) SLA experienced more than 100 fires (all causes) in five years and between 40 and 70 fires occurred at six locations along the south coast (Figure 20). Of the latter, four of those were in the Shoalhaven (Part B) and two in the Eurobodalla SLAs.

High numbers (approximately 40 fires) were only recorded in the suburb that experienced more 100 fires overall. However, overall, the level of causal attributions was again low in most suburbs recording high numbers of fires, with typically only 15 to 30 percent of fires in each suburb being recorded as deliberate. However, deliberate causes commonly comprised between 40 and 70 percent of known causes in suburbs in which the NSWRFS attended more than five fires per year. There were six suburbs in the Shoalhaven (Part B) SLA, and one suburb in the Shoalhaven (Part A) SLA where the actual rate of deliberate fires was within this range. Many of these locations affected are associated with an influx of visitors, particularly during the Christmas–New Year period.

Illawarra: Fires in the Illawarra region were concentrated within a small number of suburbs. Approximately 60 percent of all fires attended by the NSWRFS in the Illawarra region, occurred in the six suburbs recording 25 fires in five years (Figure 20). Approximately one-fifth of all fires occurred in one suburb in the Shellharbour SLA that recorded 96 fires. Another two suburbs in that SLA recorded 40 and 45 fires. Between 48 to 64 percent of fires in these three locations were documented as deliberately lit. The concentrated nature of deliberate fires in the Illawarra region is exemplified by the observation that 40 percent of deliberate fires in the Illawarra occurred in two suburbs; approximately 70 percent occurred in five suburbs (Figure 21).

Hunter: Fires in the Hunter region tended to be more evenly distributed than many other areas. Notably, five suburbs recorded 50 or more fires in five years and another 20 documented 25 fires or more, but these locations only accounted for 18 and 42 percent, respectively, of all fires attended in the region (Figure 20). The highest total number of fires occurred in the Singleton, Cessnock and Muswellbrook SLAs. Higher numbers were also recorded in several suburbs within the Lake Macquarie SLA that were located close to the Sydney–Newcastle freeway.

Twenty to 25 deliberate fires were recorded in two suburbs in the Lake Macquarie SLA, but these locations accounted for a small proportion of deliberate fires in the region (Figure 21). Given that the cause of 50 to 70 percent of fires was often unknown in those suburbs recording the highest numbers of fires, actual rates of deliberate fires were likely significantly higher than the 22 percent indicated in Figure 17. Deliberate causes commonly accounted for 40 to 90 percent of known causes in individual suburbs within the Hunter region where there were 10 or more fires in five years.

North Coast: This region recorded the second highest number of fires of any region in the state. One location, in the Kempsey SLA, recorded in excess of 200 fires in five years, having the highest incidence of fires of any single location in the state (NSWRFS only). Another two locations recorded from 100 to 150 fires, with a further three – in the Coffs Harbour (Part B), Greater Taree, Great Lakes SLAs – documenting between 80 and 95 fires. However, high numbers of fires were not restricted to these locations, with the 13 locations recording 50 or more fires in five years accounted for just 29 percent of fires in the North Coast region. Locations recording 25 or more fires in five years accounted for 60 percent of all fires in the region.

The levels of causal attribution were highly variable across the North Coast region. This necessarily affected the trends observed for deliberate fires. For example, the cause of more than 80 percent of fires in one suburb that recorded 200 fires in total was listed as unknown; only 6.6 percent in that suburb were identified as deliberate. Twenty-four percent of fires in locations recording more than 30 fires in five years were deliberately lit, but the cause of 54 percent of fires in these locations was unknown. Deliberate causes were responsible for 52 percent and 44 percent of known causes for locations documenting more than 50 and more than 20 fires (all causes) in five years.

Northern Rivers: Low numbers of fires (all causes) occurred across the Northern Rivers region; only two locations – Grafton and Kyogle SLAs – recorded 50 to 60 fires in five years and only 10 locations recorded more than five fires per year. These 10 locations accounted for only 22 percent of fires in the Northern Rivers region.

Only 13.8 percent of fires in the Northern Rivers region were identified as deliberate, with two locations recording 10 or more deliberate fires in five years. However, the cause of 58 percent of fires in the region was unknown. Nevertheless, deliberate fires on average accounted for 41 percent of known causes of fires in locations recording 10 or more fires in total in five years.

Blue Mountains: No locations in the Blue Mountains region recorded more than 50 fires in five years. The highest numbers, approximately 40 fires, occurred at two locations in the Greater Lithgow and Oberon SLAs. The four locations that recorded more than 25 fires in five years accounted for one-third of fires in the region (Figure 20).

The highest number (n=28) and highest percentage (85%) of deliberate fires occurred at one location in the Blue Mountains SLA. However, this location was distinguished by having a high proportion of causal attributions (90% compared with typical values of 40 to 60%). Deliberate fires commonly accounted for 30 to 70 percent of known causes in individual suburbs recording 10 or more fires (all causes) in five years.

Explorer Country: Fires west of the Great Dividing Range were principally associated with major regional centres. Just over one-fifth of fires in the Explorer Country region occurred in the three locations that recorded 100 to 200 fires; namely Dubbo, Orange and Mudgee. A further three locations – Coonabarabran, Goulburn and Narromine – experienced 50 to 100 fires. The number and proportion of deliberate fires in Explorer Country was low, particularly given that the cause of 65 percent of fires was known. Only five suburbs in this region recorded more than 10 deliberate fires. Approximately 60 percent of all deliberate fires in Explorer Country occurred in the 12 locations that recorded five or more deliberate fires in five years. The incidence of natural fires is high across the region, with natural fires accounting for one-third to half of all fires for individual locations.

The Murray: Albury, Deniliquin and Jindera were the only locations in the Murray region that recorded more than 25 fires. Collectively, these three locations accounted for one-fifth of fires in the Murray region. Overall, the number of fires and the number of deliberate lightings was low. Albury was the only location to record more than 10 deliberate lightings. However, again the cause of almost half of all fires was unknown.

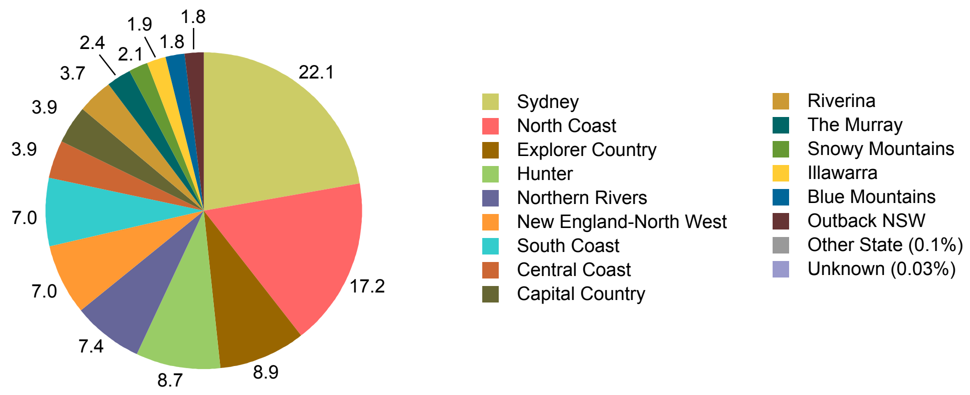
Snowy Mountains: Twenty percent of fires in the Snowy Mountains region occurred in two locations in the Cooma and Tumbarumba SLAs. These were the only locations in this region to record 50 fires in total in five years. Another two locations, both in the Tumut SLA, recorded 25 fires during the five-year period. The number and proportion of deliberate lightings was low; only three locations recorded five to 10 deliberate fires in five years. Most fires of known cause in this region resulted from accidental and natural causes.

New England–North West: The highest number of fires in the New England–North West region occurred at one location in the Inverell SLA. Fires in this location accounted for eight percent of fires in the New England–North West region. Approximately 40 percent of fires within that location resulted from accidental causes, with 44 out 55 accidental fires stemming from the inadequate control of a fire. More than 50 fires were observed in eight locations in the New England–North West region. These were primarily associated with the major urban centres of Inverell, Tingha, Tamworth, Narrabri, Armidale, Moree, Ashford and Gilgai. These locations accounted for 35 percent of fires in the district. Six locations in the New England–North West region recorded 10 or more deliberate fires. These accounted for almost half the deliberate lightings in the region. Overall, the proportion of deliberate fires was low, accounting for just 22 percent of known causes.

Outback: Two locations in the Outback region – in the Wentworth and Bourke SLAs – recorded in excess of 50 fires, collectively accounting for 35 percent of fires attended in the region. The six locations in the Outback that recorded greater than 25 fires accounted for 65 percent of fires in the region (Figure 20). More than 25 deliberate fires were recorded in a single location within the Wentworth SLA. This suburb was also characterised by a high concentration of accidental and unknown fires. Only one other location – in the Cobar SLA – recorded greater than 10 deliberate fires. Overall there were low levels of causal attribution across the region.

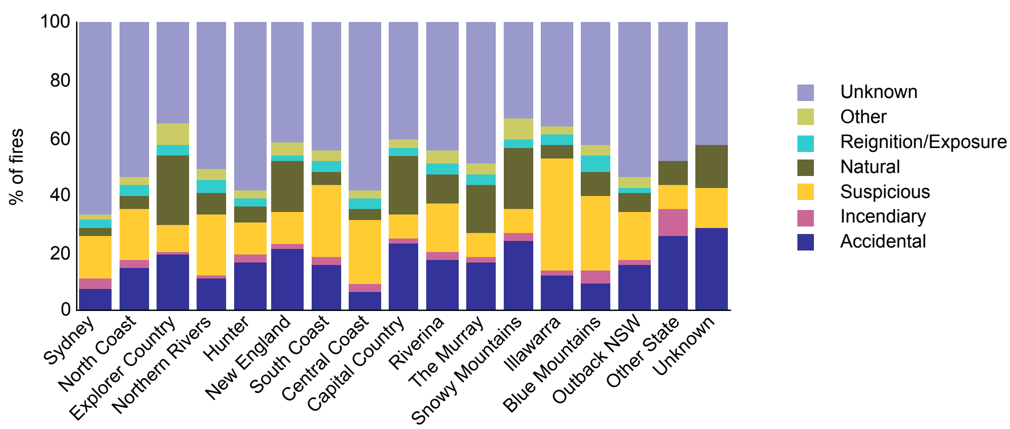
Non-deliberate child fires: There was only one case where more than five child-fires were recorded in the same suburb. This occurred in the Outback region.

Figure 16: Fires of all causes, by region (percent)



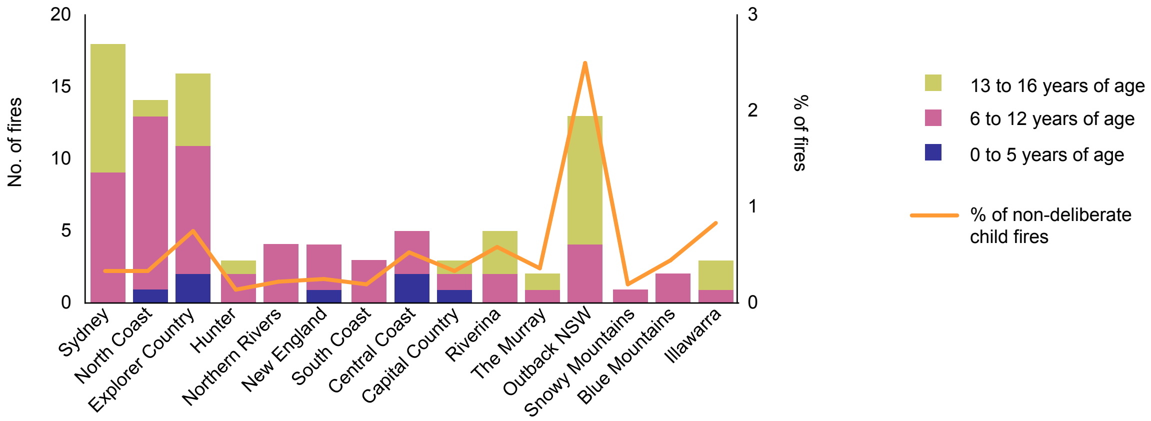
Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Figure 17: Region, by fire cause (percent)



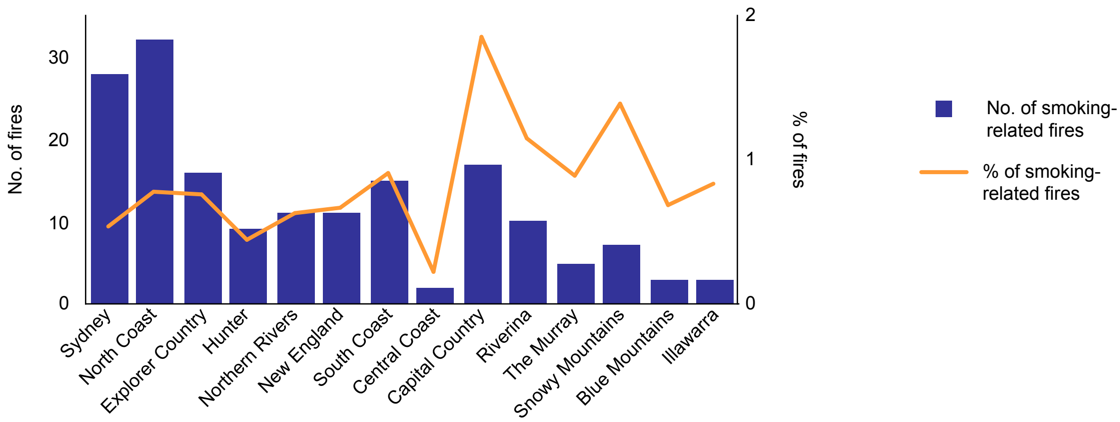
Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Figure 18: Non-deliberate child fires, by age and region



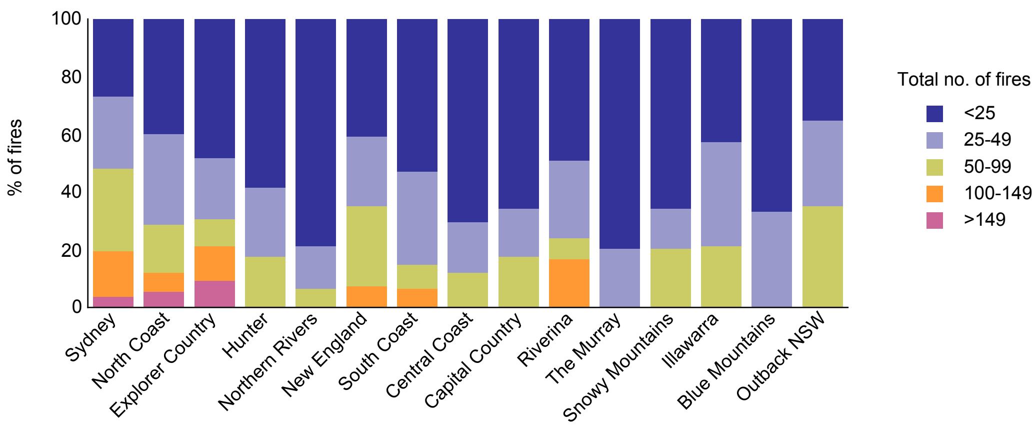
Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Figure 19: Smoking-related fires, by region



Source: NSWRFS 1999–2000 to 2003–04 [computer file]

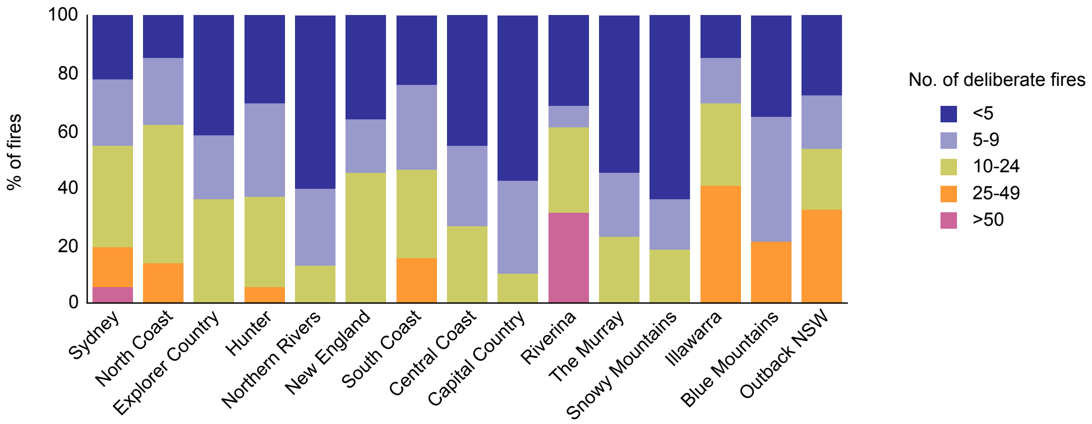
Figure 20: Fire frequency distributions, by region (percent)[a]



a: percentage of fires in each region that occurred within postcodes that recorded numbers of fires (all causes) within the specified ranges for a five-year period

Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Figure 21: Deliberate fire frequency distributions, by region (percent)[a]



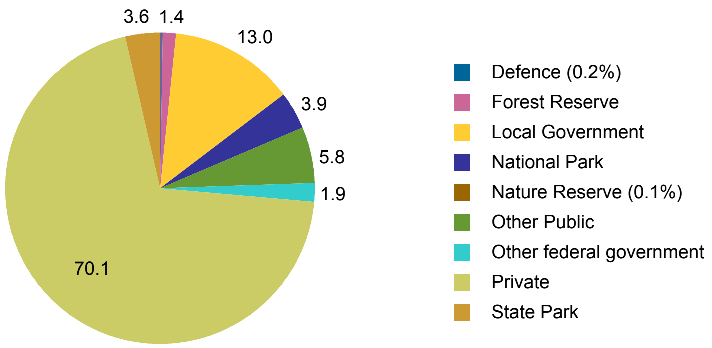
a: percentage of deliberate fires in each region that occurred within postcodes that recorded numbers of fires (all causes) within the specified ranges for a five-year period

Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Tenure

The tenure of land on which fires occurred was only documented in 36 percent of cases. The majority of these were on private land, followed by local government, and other public land, national parks and state forests (Figure 22).

Figure 22: Land tenure (percent)[a]



a: only includes the 36 percent of cases where tenure was identified

Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Timing

The timing of fires is examined by week of the year, day of the week and time of the day.

Week of the year

Two distinct phases of activity are observed within the NSW bushfire seasons. The first occurs from mid August to mid October, the second from mid December to the end of January. Both the devastating fires of 2001–2002 and 2003–03 occurred during the latter interval. The NSWRFS attended the greatest number of fires (all causes) during the August to October peak (Figure 23). This trend is in marked contrast to that observed for the NSWFB.

The general distribution described above represents an amalgamation of trends as the timing of fires is influenced by many different factors. One of the most important is cause. Accidental fires typically peak during mid August, although progressively smaller peaks occurred in December–January and April–May. In contrast, natural fires principally occurred during the December–January period. The incidence of deliberate fires tended to be high during both periods.

Deliberate causes constituted the highest proportion of deliberate fires during the December–January peak, coinciding with some most devastating fires in NSW recent history. However, this largely reflects the fact that the levels of causal attribution were also markedly higher during December–January than during August–October, and any suggestion that deliberate firesetting actually increases during this potentially more adverse period should be regarded with caution.

The intimate relationship between vegetation fires and weather is clearly evidenced by the close correspondence between increased numbers of fires (Figure 24) during periods of low rainfall within individual seasons (Figure 25, Figure 26, Figure 27). The increase in numbers of fires in August coincides with onset of dry conditions in late winter and early spring across most of the state, but subtle differences were evident between seasons.

In 2000–01, spring fires were curtailed by the late October–November rains, which occurred over most of eastern NSW. A small increase in fire activity was subsequently evident around the Christmas–New Year period. These fluctuations were evident for deliberate, non-deliberate, and unknown fires alike (Figure 28).

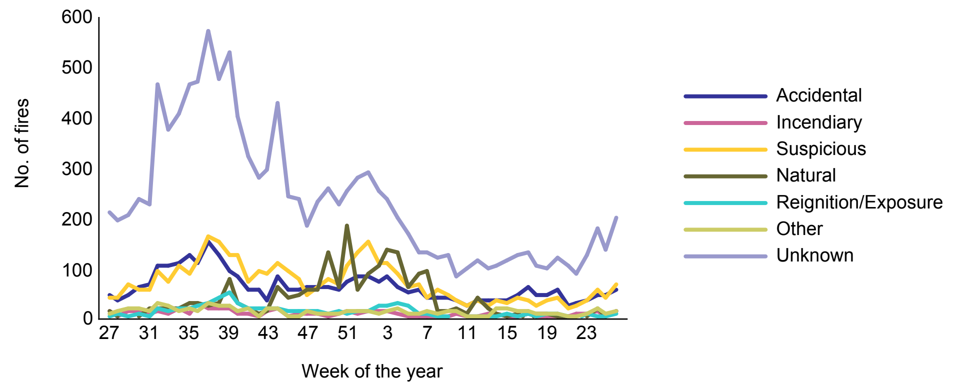
Low spring and summer rainfall occurred over much of NSW in 2001–02. This was concomitant with high numbers of fires from mid August onwards. Three distinct periods of high total fire numbers occurred in 2001–02: August, late September to mid November and late December to late January. The latter was associated with devastating fires in the Sydney and surrounding regions. In contrast to 2000–01, there were marked differences in the levels of causal attributions of fires across the season. Lower rates of causal attribution were evident during the August–October period compared to the December–January period (Figure 29). Despite this, there were strong parallels between fluctuations in non-deliberate and deliberate fires across the season. A spike in the number of deliberate fires was evident in the last week of December, when fire conditions were particularly adverse, but otherwise the number of deliberate fires remained comparatively low during the December–January period. The 2001–02 bushfire season was curtailed by February rains across most of eastern parts of the state.

High numbers of fires were evident as the 2001–02 season progressed, although again the most extensive and destructive fires occurred during the December–January period. July 2002 to February 2003 was coincident with exceptionally low winter, spring and summer rainfall conditions across most of NSW – a manifestation of the 2002–03 El Niño-like conditions. Notable disparities between this and previous seasons included the markedly earlier start to the season and the consistently high, as opposed to spiked, distribution of fire numbers. There were marked differences in the levels of causal attributions across that season, with the level of ‘known’ attributions increasing as the bushfire season progressed (Figure 30). However, in contrast to 2001–02 the ratio of deliberate to non-deliberate fires decreased as the bushfire season progressed; deliberate fires were noticeably less frequent than non-deliberate fires from November to February.

Strong parallels are evident between the 2003–04 and 2000–01 fire seasons; a distinct spike in spring fires (August to early October), with a smaller spike during the Christmas–New Year period. Low summer fire numbers were commensurate with moderate but consistent spring and summer rainfall. The most unusual aspect of 2003–04 was the subsequent increase in fire numbers during the April to June period. This was commensurate with abnormally low autumn and early winter rainfall.

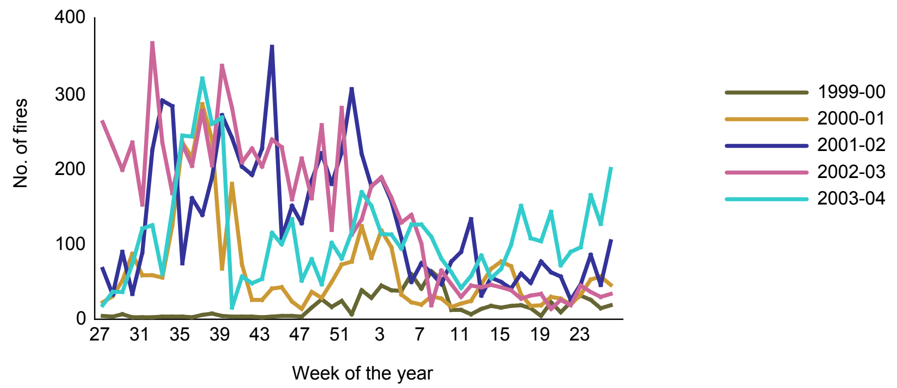
The distribution of fires varied markedly across the state, reflecting different climatic regimes across the state, but also regional differences in the principal causes of fires. The majority of fires in the South Coast, North Coast and Hunter regions occurred from August to October (weeks 32 to 45; Figure 31). The majority of fires in the Sydney region also occurred from August to October, but more fires occurred during December–January. The overwhelming majority of fires the NSWRFS attended in the Explorer Country occurred from December–January, in part a reflection of the high incidence of natural fires in that region at that time. Fires in the Northern Rivers region principally occurred during the drier months of winter and spring.

Figure 23: Week of the year, by cause (number)



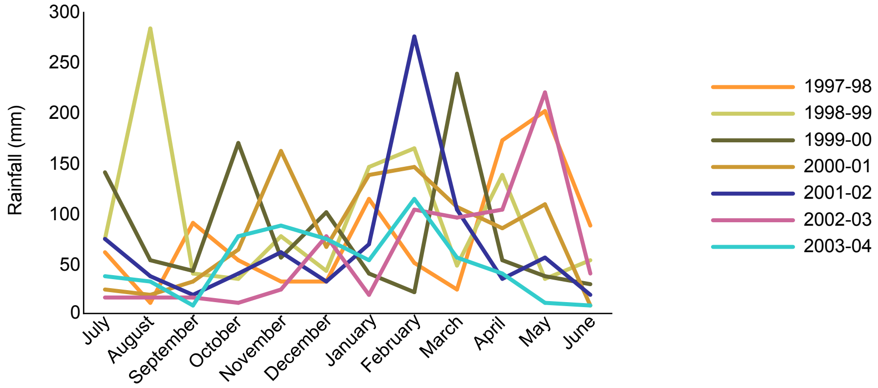
Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Figure 24: Vegetation fires each year, by week of the year (number)



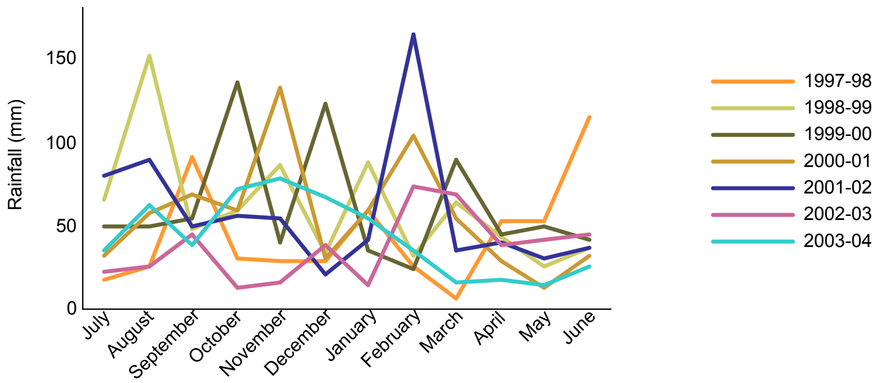
Source: NSWRFS 2000–01 to 2003–04 [computer file]

Figure 25: Metropolitan West, district average rainfall, 1997–98 to 2003–04 (number)



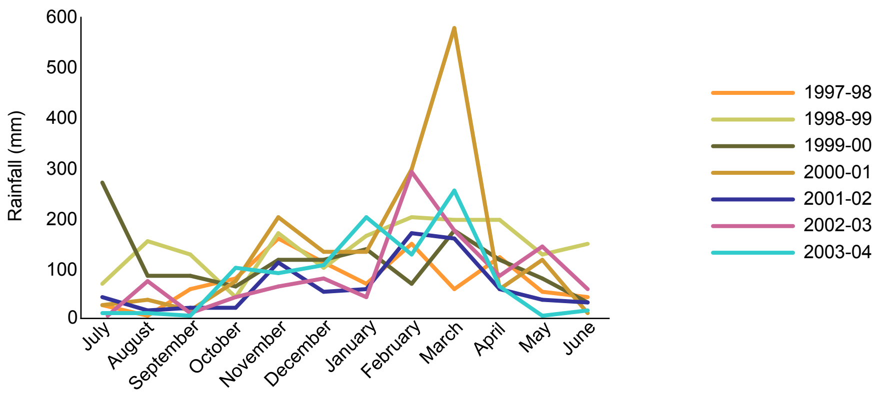
Source: Australian Bureau of Meteorology [computer file]

Figure 26: Southeast Tableland, district average rainfall, 1997–98 to 2003–04 (number)



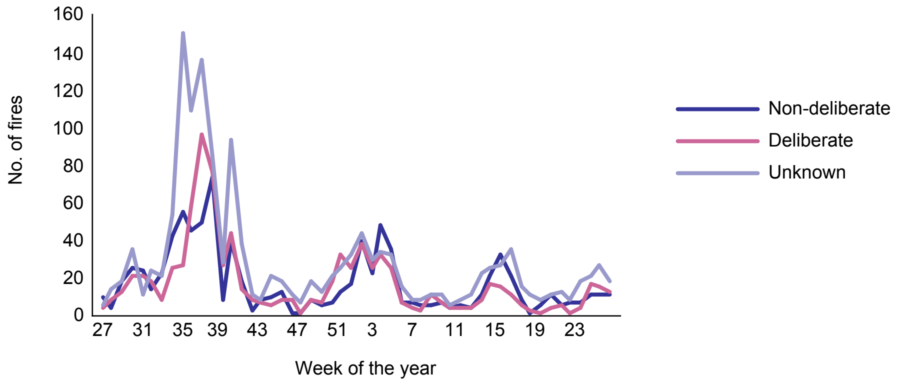
Source: Australian Bureau of Meteorology [computer file]

Figure 27: Lower North Coast, district average rainfall, 1997–98 to 2003–04



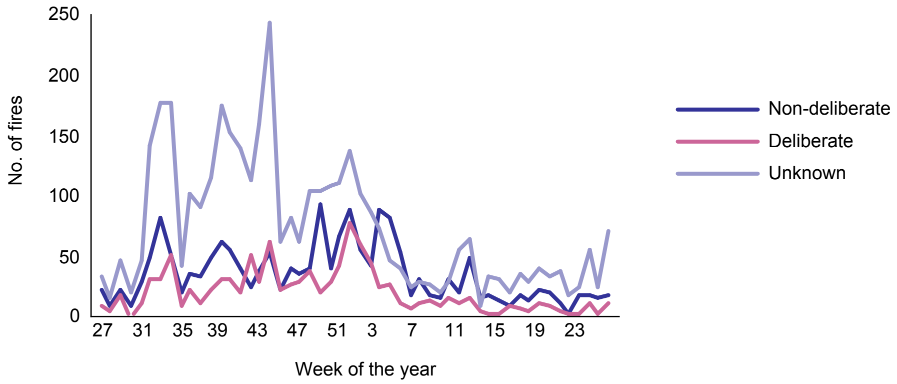
Source: Australian Bureau of Meteorology [computer file]

Figure 28: Week of the year, by cause for 2000–01 (number)



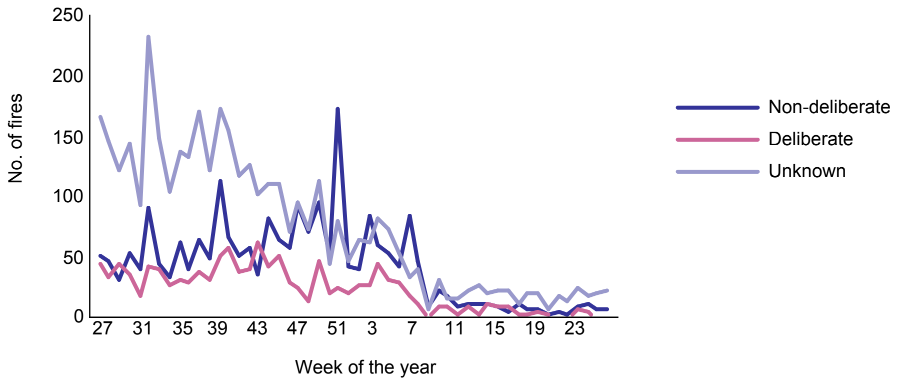
Source: NSWRFS 2000–01 [computer file]

Figure 29: Week of the year, by cause for 2001–02 (number)



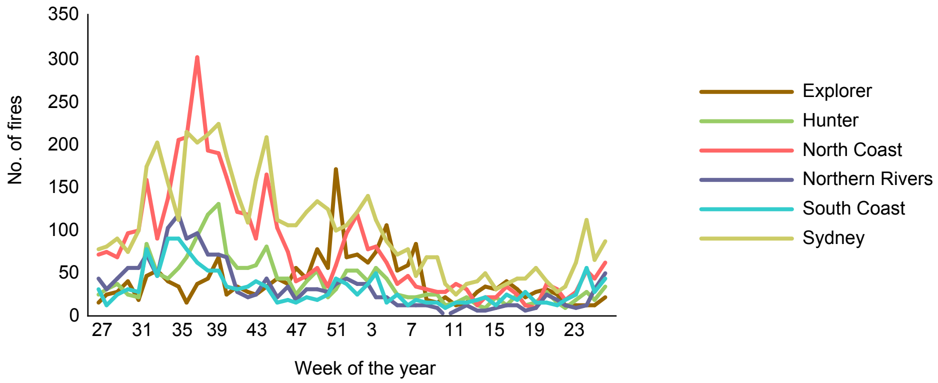
Source: NSWRFS 2001–02 [computer file]

Figure 30: Week of the year, by cause for 2002–03 (number)



Source: NSWRFS 2001–02 [computer file]

Figure 31: Week of the year, by region (number)



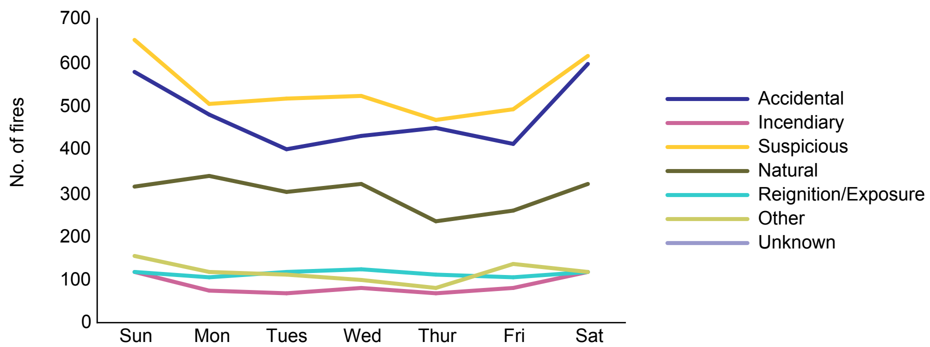
Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Day of the week

On average, the NSWRFS was 30 percent more likely to attend fires on Saturday and Sunday than on the average weekday. However, the likelihood of weekend fires was cause-specific. Notably, fires identified as incendiary were approximately 50 to 55 percent more likely to occur on a weekend whereas suspicious fires were only 23 and 30 percent more likely to occur on Saturday and Sunday respectively (Figure 32). Accidental fires were the only non-deliberate causal category to record a weekend effect, being 33 to 37 percent more likely to occur on Saturday and Sunday. Fires of unknown cause were also likely to be 33 to 38 percent more likely on weekends, highlighting that the majority of these fires resulted from human causes, be that accidental or deliberate in nature.

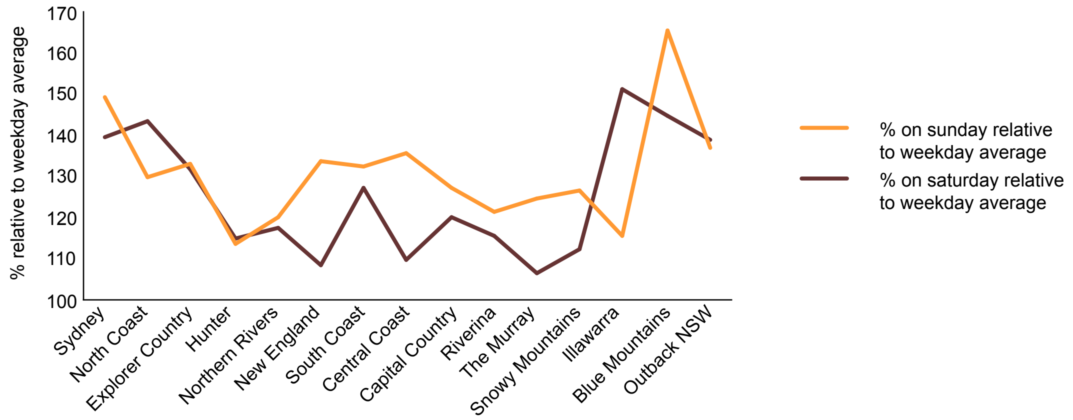
The tendency for the numbers of fires to increase on weekends was observed across all regions of NSW, although the degree to which this manifested was variable (Figure 33). Notably, high proportions of weekend fires were particularly evident for Sydney, the Blue Mountains, Illawarra, North Coast, and Outback regions. In the Blue Mountains, fires were 45 percent more likely to occur on Saturday and 65 percent more likely to occur on Sunday than on the average weekday. In the Sydney region, 39 and 49 percent of fires occurred on Saturday and Sunday respectively. Overall, lower weekend biases occurred in more distant regional areas. Outback NSW was a notable exception. Some regional differences in the tendency for Sunday versus Saturday fires were also evident.

Figure 32: Day of the week, by cause (number)



Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Figure 33: Weekend fires relative to the weekday average, by region[a]



a: regions arranged in order of decreasing total fire number

Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Time of day

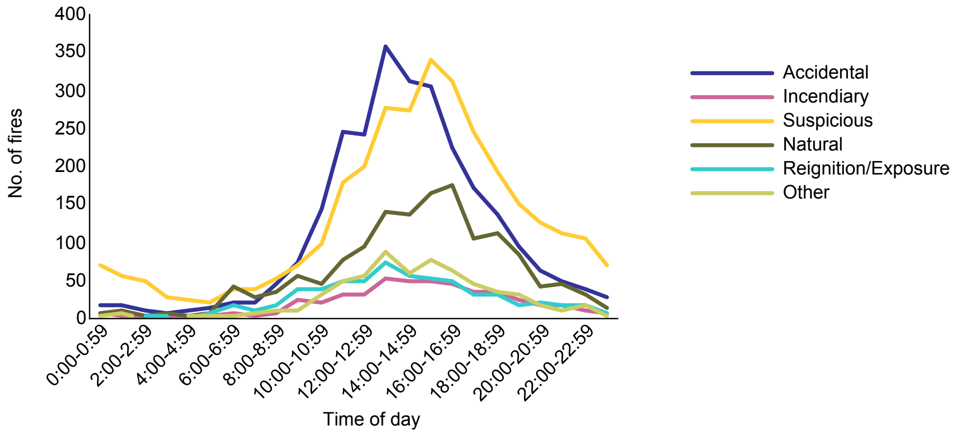
Data on the time of day was available for 78 percent of fires but detection time and cause was only known in 38 percent of cases. The timing of fires varied subtly between causal categories (Figure 34). Peak numbers of fires resulting from accidental, other and reignition/exposure occurred between 1 and 2 pm, whereas the highest number of natural fires occurred between 3 and 5 pm. As observed elsewhere, the trend for suspicious fires differed somewhat to that observed for accidental fires, with peak numbers occurring around 3 to 5 pm. There was also a greater incidence of deliberate fires during the night.

Thirty-two percent of suspicious fires occurred between 6 pm and 6 am, compared to 18 percent of accidental fires. Similarly, 13 percent of suspicious fires occurred between 10 pm and 6 am as compared with five percent of accidental fires. Interestingly, there were no clear discernible differences between the timing of incendiary and accidental fires, possibly indicating that suspicious and incendiary fires derive from different causal subsets.

The proportion of all deliberate daytime fires (8 am to 6 pm) that occurred between 4 and 6 pm varied substantially across regions, from a low of 21 and 25 percent in the Central Coast and Snowy Mountains respectively, up to 41 and 42 percent in the Murray and Outback regions (Figure 35). Between 34 and 37 percent of all daytime deliberate fires in the Sydney, Explorer Country, Illawarra, Riverina and Blue Mountains regions occurred within this timeframe.

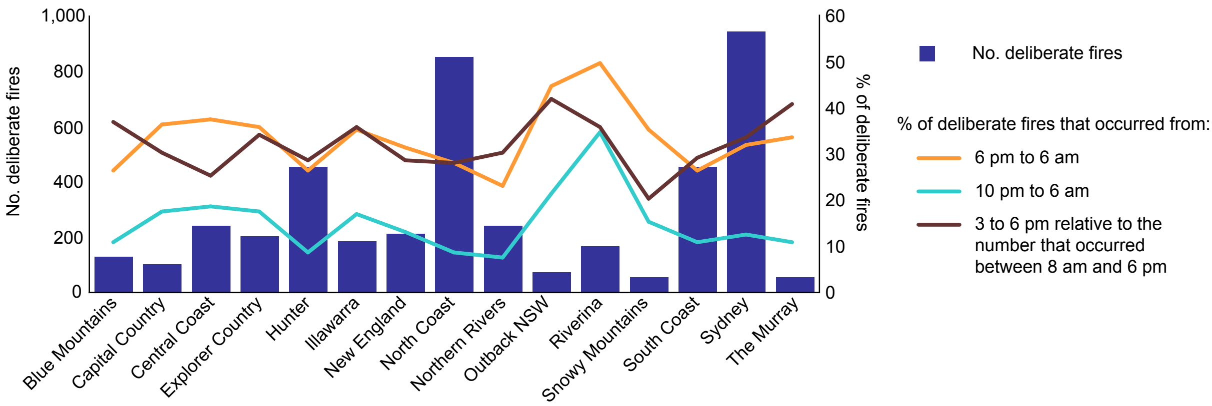
The Riverina and Outback regions recorded the highest proportion of deliberate fires between the hours of 6 pm and 6 am. The Riverina also experienced a substantially higher proportion of fires that occurred between the hours of 10 pm and 6 am. A low percentage of deliberate NSWRFS-attended fires in the Hunter, Northern Rivers and South Coast regions occurred between 6 pm and 6 am.

Figure 34: Time of day, by cause (number)



Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Figure 35: Deliberate fires, by time of day for each region



Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Area burned

The area burned by fire was only available in 40 percent of cases. Large fires typically accounted for the greatest total area burned and are statistically more likely to be recorded than small fires. Hence, estimates based on the absolute areas burned are likely to be quite accurate.

The size distribution of fires the NSWRFS attended is largely in accord with that observed elsewhere; the majority of fires were small, and the total number of fires decreased with increased size, albeit with the characteristic humps for the 10 to 49.9 ha and the 100 to 499 ha categories. Of those fires where the size was known, 40 percent burned less than one hectare and three-quarters burned less than 10 ha.

Although this general distribution was evident irrespective of cause (Figure 36), there were subtle differences in size distribution of fires based on cause (Figure 37). Overall, the proportion of natural fires increased with increased fire size. The largest natural fire occurred in January 2003, in the Snowy Mountains region. This was the only fire of any cause during the 1999–2000 to 2003–04 period to exceed 100,000 ha. There were 33 natural fires greater than 1000 ha, 12 fires of between 2,000 and 5,000 ha, and eight greater than 10,000 ha.

The proportion of accidental fires remained comparatively constant across of area categories up to 50,000 ha. The largest accidental fire, which was caused by inadequate control of an open fire, burned 30,000 ha in the Hunter region during November 2001. All other non-deliberate fires were comparatively small. The largest fire resulting from 'other' causes burned 2,000 ha in the New England–North West region. The largest fire resulting from the rekindling of a fire occurred in the Northern Rivers region in January 2003.

Although there was some tendency for suspicious and incendiary fires to be underrepresented within the moderate-sized fire categories, deliberate causes accounted for an unusually high proportion of greater than 5,000 ha fires. The overwhelming majority of large deliberate fires occurred during 2001–02. The largest recorded incendiary fire burned 10,000 ha in the Northern Rivers region in March 2002. Another four suspicious fires burned 10,000 ha or more in NSW during the 2001–02 season. The largest suspicious fire occurred in the Hunter region on 21 December 2001 and burned 82,000 ha. During the subsequent week another two suspicious fires burned 21,300 ha to the west of Kempsey (North Coast) and 10,000 ha in the New England–North West region. Another fire of unknown cause burned a further 10,000 ha in the Hunter region between Christmas and New Year in 2001–02. The only other large suspicious fire burned 10,000 ha on the North Coast during September 2002.

A total of 1,173,114 ha were burned in fires the NSWRFS attended in the 40 percent of fires for which area data was available. The greatest total area burned in any one season occurred during 2002–03 (Figure 38). This was followed closely by 2001–02.

Statistics about the total area burned are strongly influenced by large fire events. For example, in 2001–02, 10 fires burning 10,000 ha or more accounted for 77 percent of the total area burned. Due to the higher than normal incidence of large suspicious fires, suspicious causes were a significant factor in the total area burned in 2001–02. Similarly, almost 60 percent of the 2002–03 total was burned in a single fire in the Snowy Mountains fire of January 2003; and, collectively, the five natural fires that burned in excess of 10,000 ha (including the Snowy Mountains fire) were responsible for 71 percent (391,906 ha) of the total area burned in 2002–03.

Overall, 52.9 percent of the total area burned in fires the NSWRFS attended from 1999–2000 to 2003–04 resulted from natural causes (Figure 39). The overwhelming majority of these occurred during 2002–03, and to a lesser extent 2001–02 (Figure 38).

Incendiary and suspicious fires accounted for 1.4 and 15 percent of the total area burned during the five-year period, respectively. Approximately 145,000 ha were burned by deliberate fires in 2001–02, accounting for 30 percent of the total area burned in that year. Deliberate fires burned just over 30,000 ha in 2002–03, but owing to the large area burned by natural fires, this accounted for only six percent of the total area burned.

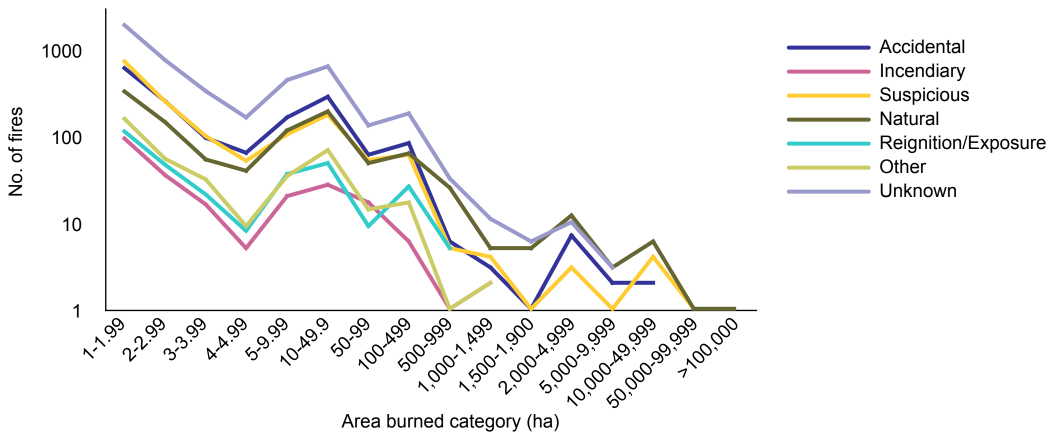
More than half the total area burned in NSW was burned in the Hunter and Snowy regions (Figure 40); a result of the very large fires that occurred in those regions during 2001–02 and 2002–03. Between six and 10 percent of the total burned occurred each in the Capital Country, New England, North Coast, and Sydney regions.

Natural fires were responsible for burning the greatest proportion of land in the Blue Mountains Capital Country, Explorer Country, Illawarra, Outback, Snowy Mountains and Sydney regions (Figure 41). Suspicious fires accounted for 40 to 45 percent of the total area burned on the North and South Coast regions, 35 percent of the land burned in the Hunter and 20 to 30 percent of land burned in the Central Coast, Northern Rivers, and New England–North West regions.

Three-quarters of the total area burned in fires NSWRFS-attended was in national parks with a further 6.4 and 3.9 percent being located in state parks and forest reserves respectively (Figure 42). This highlights the potential overlaps that exist between the NSWRFS and NSW NPWS and, to a lesser extent, the SFNSW databases.

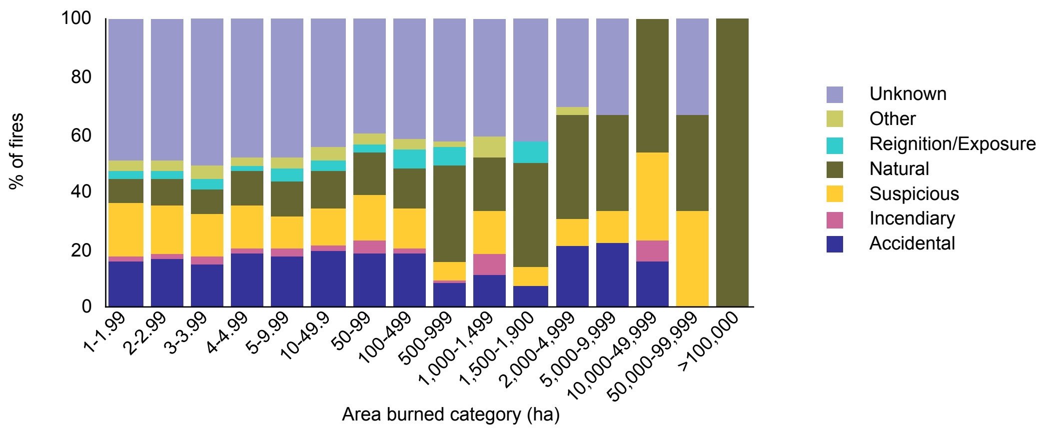
More than half the area burned was in native grasslands (Figure 43). The 28 percent 'other' refers to alpine vegetation burned during 2002–03. Approximately eight percent of the total area burned was in native eucalypt forests. A high proportion of the total area burned in mallee, native Eucalypt forests, softwood plantations and other (primarily alpine vegetation) were as a result of natural causes (Figure 44). In contrast, accidental causes were responsible for the greatest areas burned in crops, vineyards and orchards, other grasslands and unknown vegetation categories. Deliberate fires formed a higher proportion of the total area burned in native grasslands, 'other forests', and to a lesser extent in heathland, other grasslands and unknown vegetation types. A single fire of 'other' causes (unspecified) was the only known cause of land burned in plantation hardwood forests.

Figure 36: Area burned category (hectares), by cause (percent)



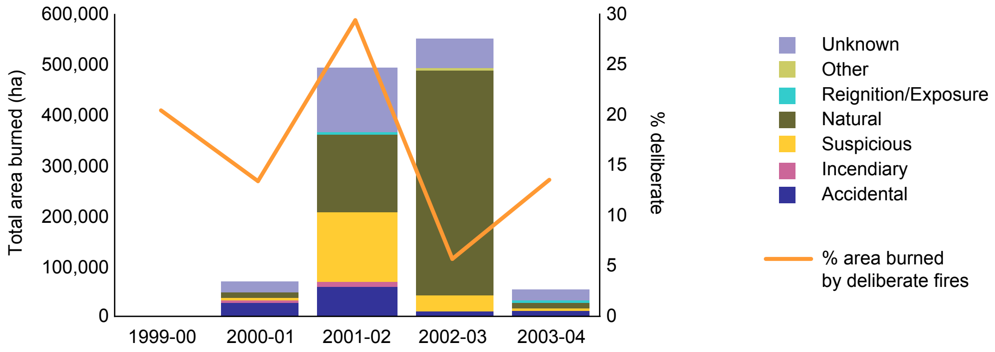
Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Figure 37: Area burned category, by cause (percent)



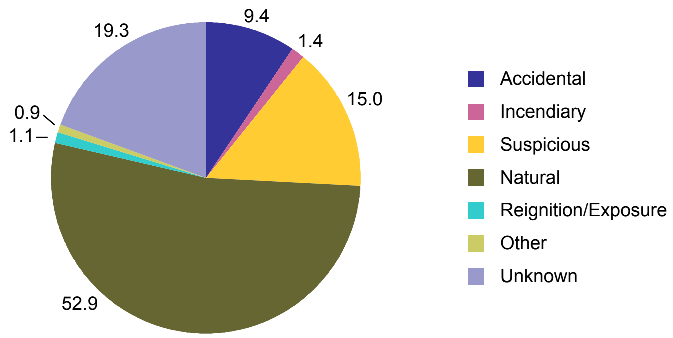
Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Figure 38: Area burned, by cause each year



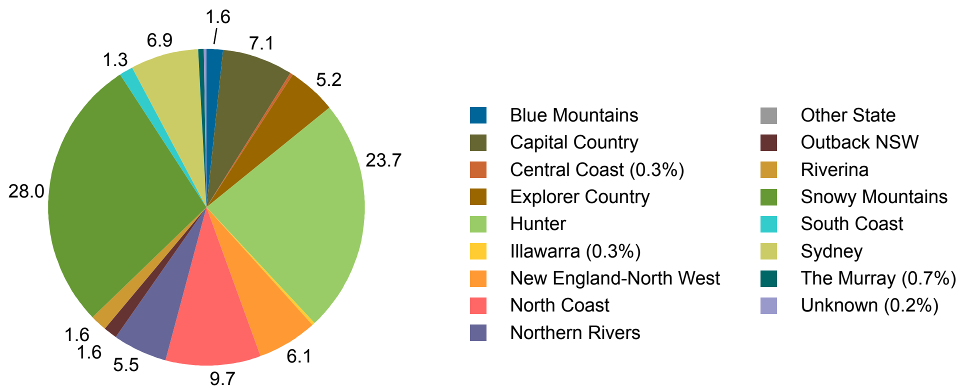
Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Figure 39: Total area burned, by cause (percent)



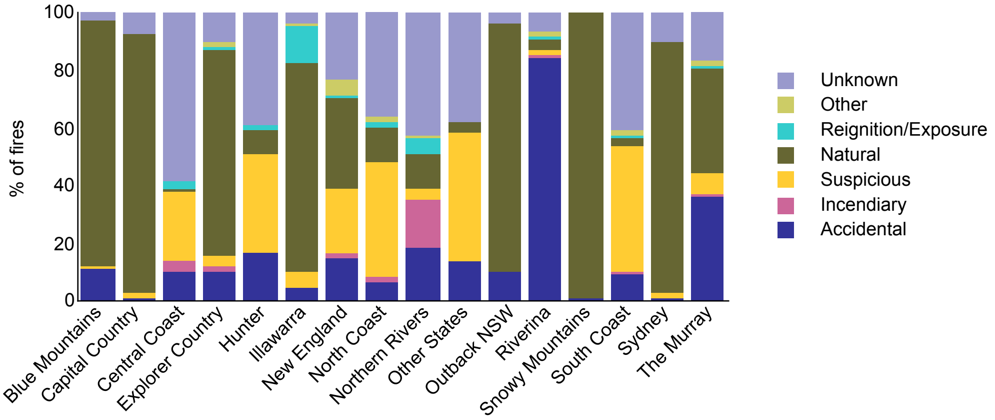
Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Figure 40: Total area burned in each region (percent)



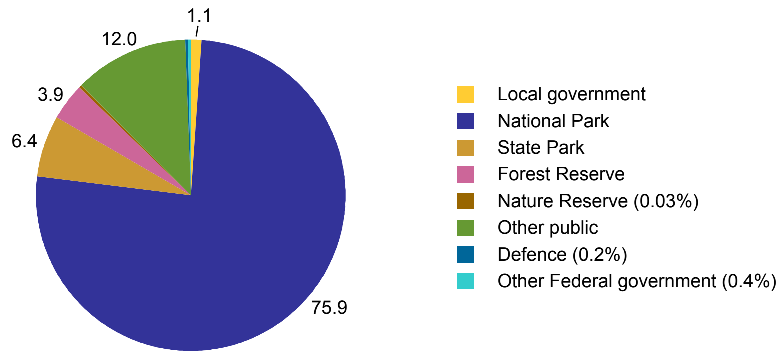
Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Figure 41: Area burned in each region, by cause (percent)



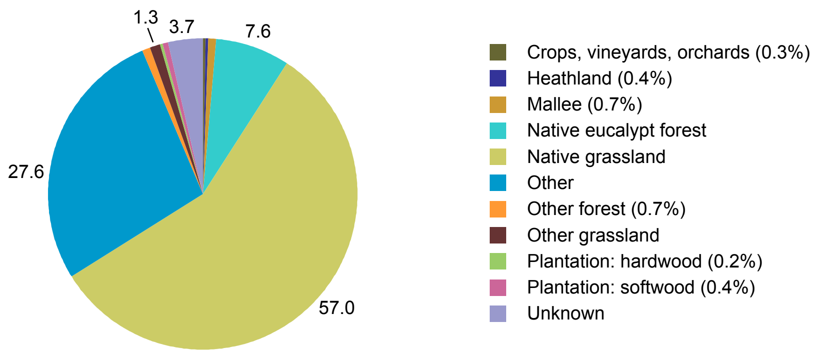
Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Figure 42: Total area burned, by tenure (percent)



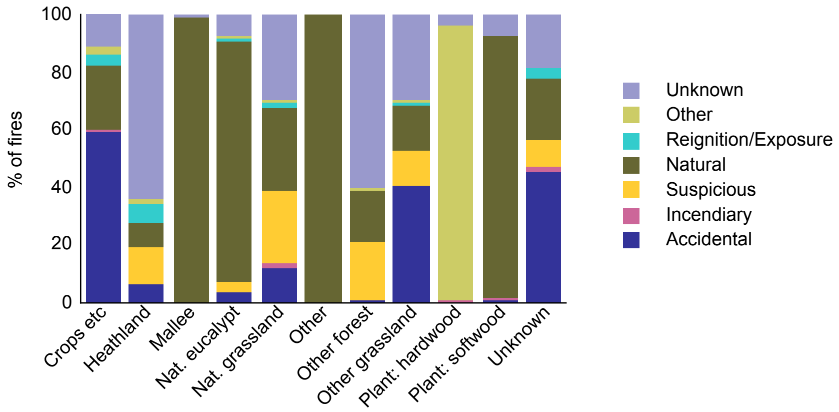
Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Figure 43: Total area burned, by vegetation-type (percent)



Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Figure 44: Total area burned in each vegetation type, by cause (percent)



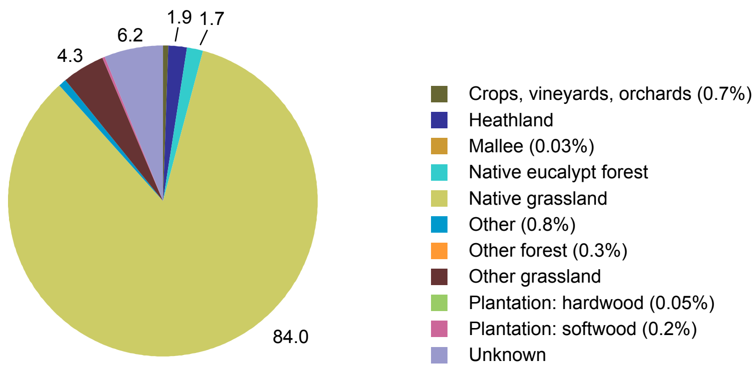
Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Vegetation

The overwhelming majority of fires the NSWRFS attended were in native grasslands (84%; Figure 45). Fires in heathland and native eucalypt forests accounted for 1.9 and 1.7 percent of fires. Approximately 0.3 percent of the fires attended occurred in either hardwood or softwood plantations.

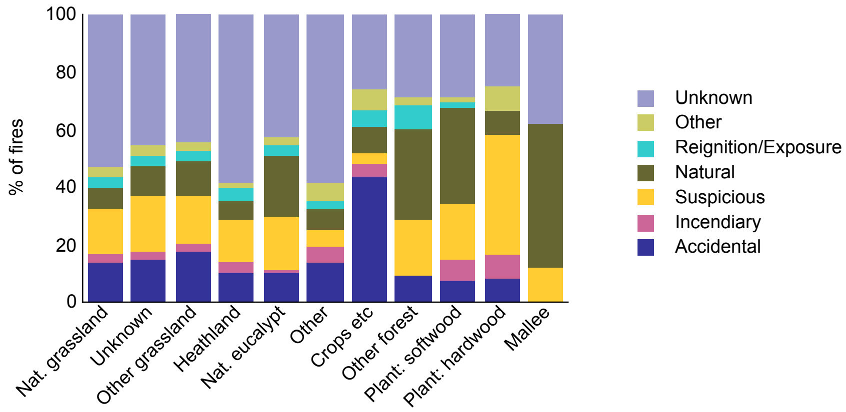
The proportion of deliberate fires was remarkably uniform across strongly contrasting vegetation types, although a considerably lower proportion of fires within the crops, vineyards, orchards, and 'other' vegetation categories resulted from this cause (Figure 46). In contrast, almost half of all fires in hardwood plantations arose from this cause. Natural causes accounted for a comparatively high proportion of fires in native eucalypt forests, 'other forests', softwood plantations and mallee. Nevertheless, the greatest number of fires resulting from this cause occurred in native and other grasslands.

Figure 45: Vegetation type (percent)



Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Figure 46: Vegetation type[a] by cause (percent)



a: Vegetation categories arranged in order of decreasing fire frequency

Source: NSWRFS 1999–2000 to 2003–04 [computer file]

New South Wales Fire Brigade analysis

Background about the NSWFB dataset and its analysis

Important information about the NSWFB dataset and the methodology employed to analyse it is outlined below:

- Fire data were sourced from Australasian Fire Authorities Council (AFAC).
- The database included data from 1997–98 to 2001–02.
- The dataset provided included fires of all causes (structural, vehicle, vegetation and other). Only vegetation fires (AIRS wildfires; Type of Incident code 160 to 179) were analysed. Hence, all references to fire refer to vegetation fires, and do not include other fire categories.
- The data were classified using Australian Incident Reporting System (AIRS) classification codes.
- The cause of fires was defined using the ignition factor variable.
- Deliberate fires include all fires classified as incendiary (AIRS ignition factor code = 110 or 120) or suspicious (AIRS ignition factor code = 210 or 220).
- Natural vegetation fires refer to all fires where the ignition factor codes were 800 to 890, which incorporate any fire resulting from a natural condition or event. For the NSWFB the breakdown of specific causes of natural fires was: high wind 27.3 percent, lightning 30.1 percent, high water (including flood) 0.9 percent, and any other natural condition (not classified [NC]/insufficient information to classify further [IO]) 41.5 percent.
- The dataset included the form of heat of ignition variable.
- Smoking-related fires were classified on the basis of: 'Form of heat of ignition'='Heat from smokers' materials' (AIRS codes 300 to 390). The cause of smoking related fires was: 82 percent accidental, 6 percent incendiary, 7 percent suspicious, and 4 percent unknown.
- All fires started by children were identified within the database as resulting from children playing and are therefore considered non-deliberate or accidental in origin. No information was available about the number of malicious fires started by children, as these fires are classified as incendiary or suspicious, and cannot be delineated from other fires included within these categories.

- The database included information about ‘type of incident’.
- Regions used in the NSWFB analysis are based on ABS (2005) tourism regions. However, there is not an exact correspondence between tourism regions used in this analysis and ABS tourism regions. In this study, assignation was based on the highest levels of concordance between postcode (provided) and tourism regions, but ABS tourism regions were constructed from smaller statistical areas that potentially crosscut suburb and postcode boundaries.
- Statistical subdivisions (SSDs) and statistical local areas (SLAs) were used to examine the distribution of fires in specific areas of NSW. Although the general structure and terminology used for SSDs and SLAs follows ABS guidelines (ABS 2001a), fundamental differences exists between the SSD and SLA used in this report and that defined by the ABS. SLA were generated from the highest levels of concordance between postal areas and SLAs using ABS (2001b) guidelines. In contrast, ABS-defined SLAs commonly crosscut postal areas and postcodes.
- The dataset supplied did not include information about the area burned.
- No information was available about the fire danger or fire restrictions at the time the fire occurred.

For more detail about these methodologies see the methodology chapter.

Overview

Fires the NSWFB attended can be summarised as follows:

- NSWFB records indicate attendance at 55,730 vegetation fires for the seasons encompassing 1997–98 to 2001–02, representing an average of over 11,000 fires per year. Actual attendances varied between a low of 7,623 in 1998–99 and 8,034 in 1999–2000 up to 14,347 in 2001–02 (Figure 47). These yearly variations were in keeping with the observations from other NSW fire agencies.
- The NSWFB attended a wide variety of incident types ranging from small vegetation fires through to very large bushfires. Sixty percent of all fires attended were grassfires, with a further 17 percent delineated as scrub, bush, and grass mixtures; another 18 percent were small vegetation fires. These types of incidents accounted for the bulk of vegetation fires attended in any one region, although the proportions of individual categories varied between regions. Forest and wood fires (greater than one hectare) comprised less than one percent of all fires attended overall, but up to five percent of fires attended in the Blue Mountains region. Overall, the proportion of deliberate fires was remarkably similar across different incident types. It is not possible to determine how many of the fires were, or had the potential (under adverse conditions) to develop into, a bushfire, although some inferences can be made.
- Deliberate causes accounted for 37 percent (14.6% incendiary, 22.6% suspicious) of all fires the NSWFB attended. This represents 56 percent of known causes of fires.
- Forty-two percent of all fires the NSWFB attended occurred in the Sydney region, with a comparatively high number also occurring in the Hunter, Illawarra, North Coast and the New England–North West regions. High rates of deliberate fires were observed across all areas that record high numbers of fires.

Cause

The cause of fires the NSWFB attended was assigned to two-thirds of all fires. Incendiary causes accounted for 14.6 percent of all fires, with deliberate fires being suspected in a further 22.6 percent of cases (Figure 48). Deliberate (incendiary and suspicious combined) fires accounted for 37 percent of all fires, representing 56 percent of cases where cause was attributed.

The percentage of deliberate fires decreased from 40 to 45 percent in 1997–98 and 1998–99 to 33 to 34 percent from 1999–2000 to 2001–02 (Figure 47), but this was counterbalanced by a higher proportion of fires of unknown causes for the latter two seasons. The highest number of deliberate fires occurred in 1997–98, followed by 2001–02 and 2000–01.

Comparatively few NSWFB-attended fires were the resulted of natural causes, accounting for just one percent of all fires attended. This compares with 8.8 percent for the NSWRFS. Accidental causes were attributed to 26 percent of all NSWFB fires.

Specific ignition factors

Form of heat of ignition: The form of heat of ignition was attributed in 60.7 percent of cases. Open flames or sparks were responsible for 50 percent of all fires (Figure 49), being singly the largest cause of both non-deliberate and deliberate fires (Figure 50). Other important causes of non-deliberate fires included smoking-related materials, fires started by hot object or friction and to a lesser extent fires started by natural or electrical sources.

Fires started by children: Non-deliberate fires started by children 16 years or younger accounted for 15.5 percent of all fires the NSWFB attended from 1997–98 to 2001–02. In the majority of cases (42%) the age of the child was unknown (Figure 51). Of those where the age was recorded, most were lit by 13 to 16 year olds (37% of non-deliberate child fires) and to a lesser extent 6 to 12 year olds (20% of non-deliberate child fires). Children five years of age or younger accounted for only 0.5 percent of non-deliberate vegetation fires started by children.

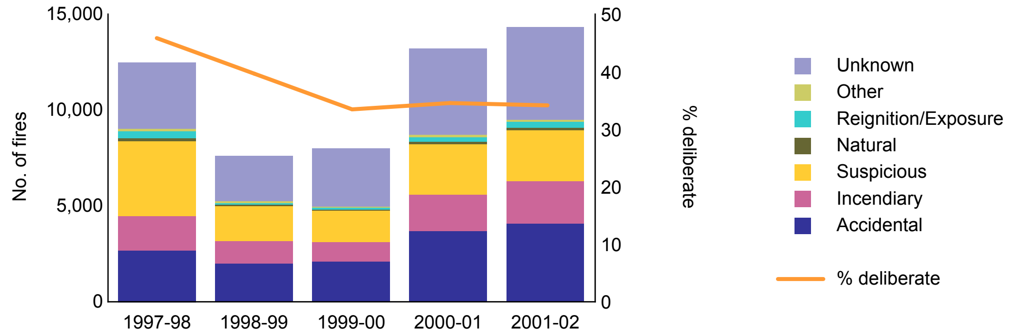
The highest number of non-deliberate child fires was recorded during 2000–01 and 2001–02 (Figure 52). Although the total number of fires started by children broadly followed the yearly fluctuation in total fire frequencies, the proportion of fires attributed to children climbed from 11 percent in 1987–88 to 17 and 19 percent during 2000–01 and 2001–02 respectively (Figure 52). It is unclear to what extent this reflects a change in the methods of recording (as potentially indicated by the high proportion of fires started by children of unknown age in 1997–98), differences in children being sited at the scene of fires, or genuine increases in the extent of children lighting fires. Excluding 1997–98 season, the proportion of fires started by individual age groups remained stable over the observation period.

As for fires generally, the vast majority of fires started by children resulted from misuse of an open flame (Figure 53), with the use of matches clearly outweighing lighters in documented cases (Figure 54). Overall, the proportions of fires children started with lighters decreased with increasing age. Unlike many jurisdictions, there was a surprisingly large array of heat of ignition factors attributed to children five years or younger.

Smoking-related fires: The NSWFB attended 3,328 fires from 1997–98 to 2001–02 where the heat of ignition was attributed to smoking-related materials, representing six percent of all fires the NSWFB attended during this five-year interval (Figure 49). Smoking-related fires were the second greatest cause of ignition after open flames and sparks. As a result of the methodology adopted in this study, 82 percent were classified accidental; six percent incendiary; seven percent suspicious; and four percent were unknown (Figure 50).

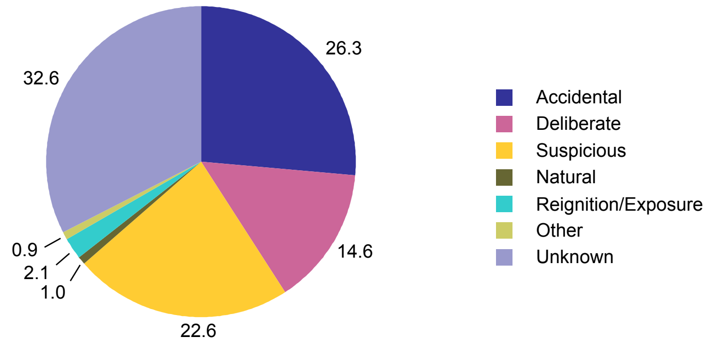
The number of fires started by smoking-related materials largely varied in accord with total fire numbers, ranging from a low of approximately 470 fires in 1998–99 and 1999–2000 to a high of 954 fires in 2001–02 (Figure 55). However, the proportion of fires attributed to smoking-related materials increasing from 5.0 percent in 1997–98 to 6.6 percent of fires in 2001–02 (Figure 55).

Figure 47: Cause, by year



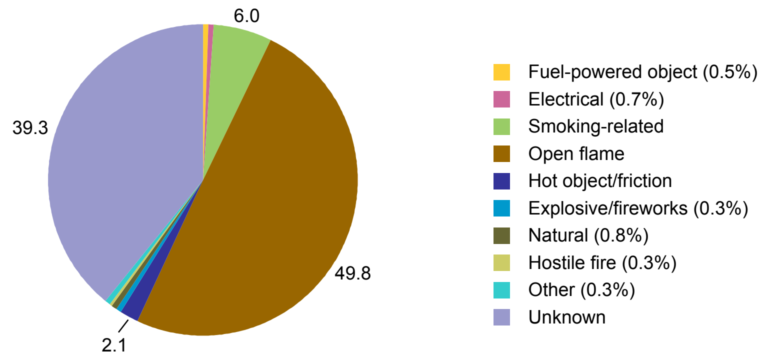
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 48: Cause (percent)



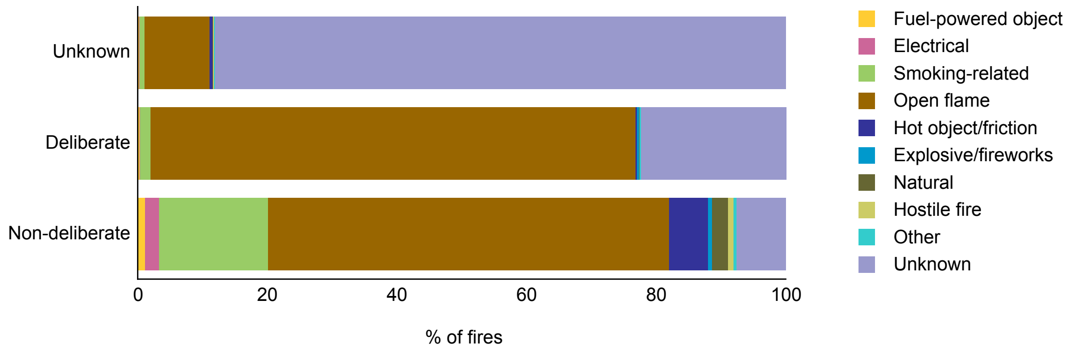
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 49: Form of heat of ignition (percent)



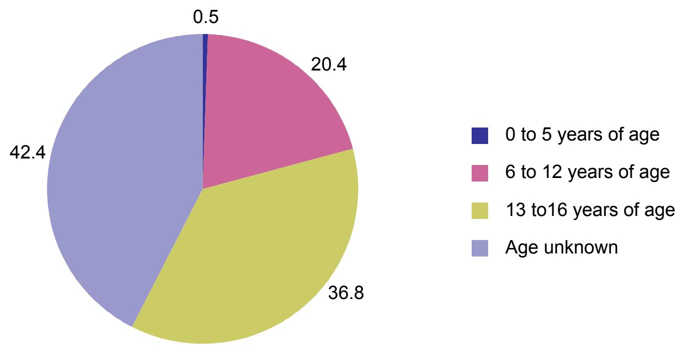
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 50: Form of heat of ignition, by cause (percent)



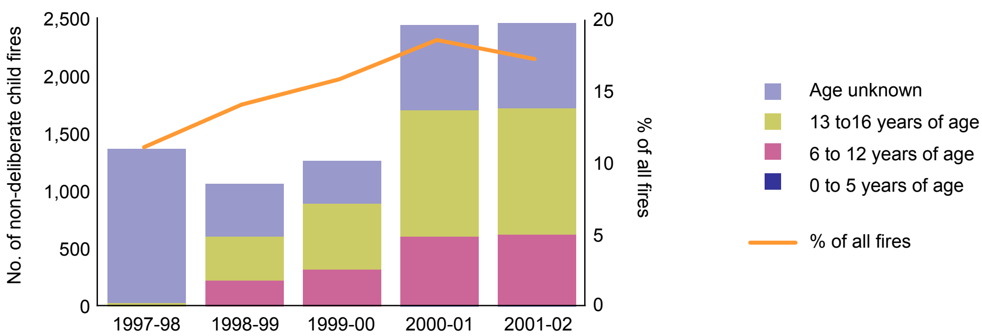
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 51: Non-deliberate child fires, by age (percent)



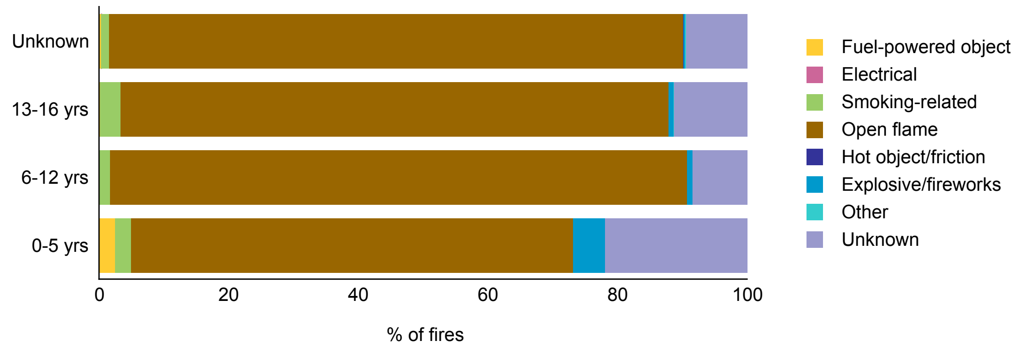
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 52: Non-deliberate child fires each year, by age



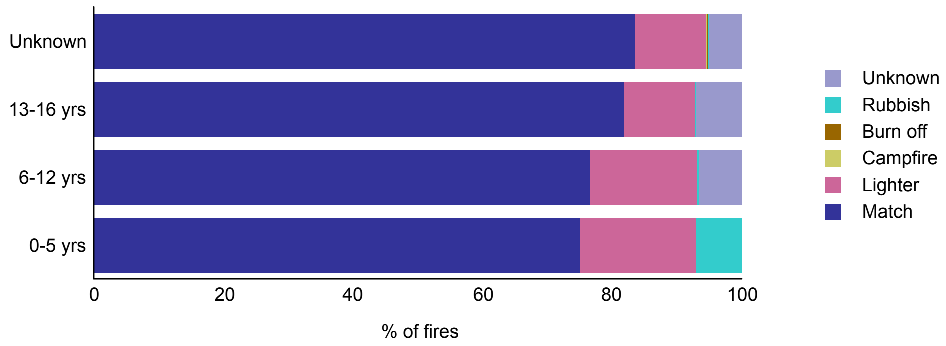
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 53: Non-deliberate child fires, by form of heat of ignition, by age group (percent)



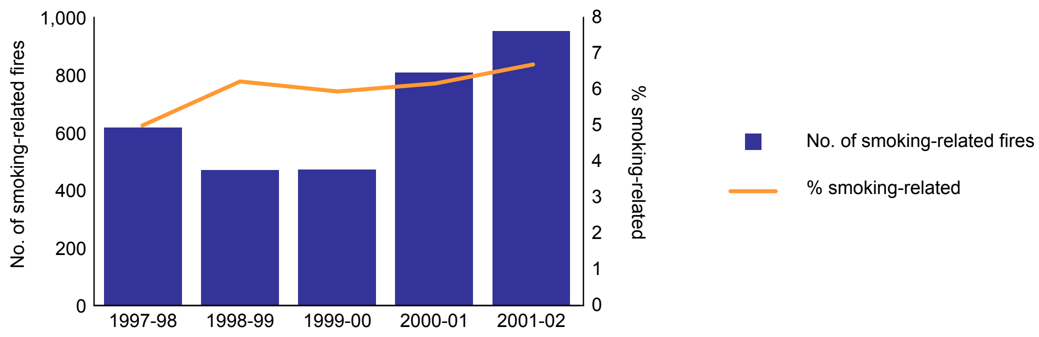
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 54: Non-deliberate child fires, by form of heat of ignition in cases resulting from an open flame or spark (percent)



Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 55: Smoking-related fires, by year



Source: NSWFB 1997–98 to 2001–02 [computer file]

Location

Information about the location of fires includes the regional distribution of fires, the distribution of fires at a postcode level within individual regions as well as details about the type of complexes where fires occurred.

Region

Regions used in the analysis of the NSWFB data are based on the 2005 ABS tourism regions (as used for the NSWRFS data; Figure 15). Forty-two percent of all vegetation fires the NSWFB attended occurred in the Sydney region. Other regions to experience high numbers of vegetation fires included the neighbouring Hunter (13%), and Illawarra regions (7%; Figure 56).

Overall, there was excellent correlation between the number of deliberate fires and the total number of fires in each region (r=.99; p<.001). Nevertheless, some variation was evident in the actual percentage of fires recorded as deliberate, particularly for regions with low total numbers of fires. The highest percentage of deliberate fires occurred in the Outback (55%), Illawarra (47%), North and Central Coast regions (44%), and the Hunter (40%; Figure 57). The lowest proportion of deliberate fires occurred in the Capital Country (15%), South Coast (16%) and Northern Rivers (21%) regions. However, the latter were also three regions that recorded among the lowest rates of 'known' causes (30 to 50%). Deliberate fires typically accounted for 40 to 65 percent of 'known' causal attributions (deliberate and non-deliberate combined) in most regions. Exceptions included the Outback where the rate was 83 percent, and the Capital Country region, which had rates of 30 percent.

More than half of all non-deliberate child fires the NSWFB attended occurred in the Sydney region (Figure 58). A further 10 percent occurred in the Hunter, 7.7 percent in the New England–North West and 6.6 percent in the Illawarra. Overall there was a strong correlation between the number of non-deliberate child fires and the total number of fires documented in individual regions (r=.99; p<.001). However, non-deliberate child fires accounted for the highest proportion of fires in the Sydney and New England–North West regions (20%), whereas in regions where the total fire number was less than 1,300 (in five years), non-deliberate child fires accounted for only four to nine percent of all fires (Figure 59).

The vast majority of smoking-related fires also occurred in the Sydney region (57%), followed distantly by the Illawarra (11%) and Hunter (9.5%) regions (Figure 60). The percentage of smoking-related fires was highest in the Illawarra (9.3%), Sydney (8.1%), and the Murray (8.6%) regions. In contrast, only one to 1.5 percent of all fires in the New England–North West, Blue Mountains and Outback originated from smoking-related materials (Figure 60).

Postcode/statistical local area

This section examines the distribution of fires, generally, and deliberate fires specifically, between postcodes within individual regions. It should be recognised that the data for many regional areas is likely complicated by the fact that both the NSWFB and the NSWRFS may attend fires in the same postcode. The following trends are based on NSWFB data only, and therefore represent the trends that primarily occur in major urban centres within each region.

Sydney: The NSWFB attended over 23,000 fires in total (all causes), in over 200 postcodes across the Sydney region during the five-year period. However, the geographical distribution of fires was extremely heterogeneous, with a number of regions and/or postcodes accounting for a disproportionately high number of all fires.

Nine postcodes in the Sydney region experienced in excess of 500 fires in the five-year period, 15 that recorded 200 to 499, and 22 where there were 100 to 199 fires in five years. Postcodes that recorded greater than 500, 200 to 499, and 100 to 199 fires accounted for 42 percent, 19 percent and 11 percent of all fires in the Sydney region, respectively. Collectively, postcodes recording in excess of 20 fires per year accounted for approximately three-quarters of all fires in the region.

The distribution of vegetation fires within postcodes and SSDs in the Sydney region is summarised in Table 4. Based on the distribution of fires, these SSD can be subdivided into three general groups; those experiencing greater than 3,000, 1,000 to 1,400 and less than 700 fires of all causes in five years. Characteristics of SSD within these categories are further discussed below.

SSDs that experienced high total fire numbers (greater than 3,000 in five years) include the Outer South Western, Fairfield–Liverpool, Blacktown and Outer Western SSDs (Figure 61). Not surprisingly, many postcodes within these regions also recorded elevated numbers of fire. Three postcodes in the Outer South Western SSD and two postcodes each in the Fairfield–Liverpool, Blacktown, and Outer Western SSDs recorded in excess of 500 fires in five years. These were the only postcodes in the Sydney region where the NSWFB recorded fire numbers within this range. These SSDs also had a comparatively high number of postcodes within the 200 to 500 and 100 to 200 categories, when compared with other SSDs within the Sydney region. Although fires were heterogeneously distributed across each of these SSDs, higher total numbers of fires were a broad characteristic of each region. Typically, the small number of postcodes that recorded 500 or more fires and 200 or more fires in five years in each SSD accounted for 50 to 75 percent and 80 percent of all vegetation fires in these SSDs, respectively (Figure 62).

SSDs that recorded moderate numbers of fires (1,000 to 1,400 fires in five years) included the Canterbury–Bankstown, Central Western, St George–Sutherland, and the Central Northern SSDs (Figure 61). Postcodes within this range typically recorded a maximum of 100 to 199 fires in the five-year period, although one postcode in the Central Western region SSD recorded just over 200 fires during this period. Twenty to 50 percent of all fires in these four SSDs occurred in postcodes experiencing an average less than 15 fires per year (Figure 62).

SSDs that recorded low numbers of fires (less than 700 fires in five years) included the Northern Beaches, Eastern Suburbs, Lower Northern and Inner Western SSDs (Figure 61). Postcodes within these areas recording an average of 20 or more fires per year (more than 100 fires in total) were either absent or exceptionally rare. A notable exception was a single postcode in the Eastern Suburbs SSD, which recorded in excess of 200 fires in five years. Fires within that postcode accounted for one-third of all fires in the SSD (Figure 62).

The number of deliberate fires is strongly linked to total fire frequencies. Those SSDs that recorded in excess of 3,000 fires in total, namely Outer South Western Fairfield–Liverpool, Blacktown and Outer Western, recorded approximately 1,200 and 2,200 deliberate fires in five years. Collectively, these high fire SSDs accounted for three-quarters of all deliberate NSWFB-attended vegetation fires. Individual postcodes within these SSDs recorded very high numbers of deliberate fires. Notably, three postcodes in Outer South Western Sydney recorded 200 or more deliberate fires, and a further two experienced 20 to 40 deliberate fires per year. In Fairfield–Liverpool and Blacktown SSDs two suburbs were within both the greater than 200 and the 100 to 199 deliberate fire categories. In Outer Western Sydney, three postcodes recorded 200 or more deliberate fires, and one postcode, 100–199 fires.

Collectively, the 10 postcodes that recorded 200 or more deliberate fires in five years represented just one-fifth of all postcodes to have recorded a vegetation fire of any cause in the five year interval but accounted for 58 to 78 percent of all deliberate fires recorded in those SSDs (Figure 63). Moreover, these 10 postcodes accounted for half of all deliberate fires recorded in the Sydney region, and one-fifth of all deliberate fires the NSWFB attended across the state.

Those SSDs experiencing 1,000 to 1,400 fires in total, recorded between 320 and 440 deliberate fires in five years. At a maximum, there were only one or two postcodes that documented more than 50 deliberate fires in total. The SSDs with less than 700 fires in total observed between 63 and 186 deliberate fires in five years. In three of the five SSDs, no postcode experienced an average of greater than five deliberate fires per year (Figure 63).

Overall, the percentage of deliberate fires within each SSD increased as the total number of fires increased. The proportion of deliberate fires in SSDs experiencing less than 700 fires in five years was on average 20 to 25 percent. This compares with an average of 40 percent in SSDs experiencing more than 3,000 fires (Figure 61). This increase in the proportion of deliberate fires with increasing total number of fires was also evident at a statistical local area level (Figure 64), but breaks down to some extent at a postcode level, due to the inherent statistical limitations that are introduced at this level (Figure 65). Nevertheless, even at a postcode level, the minimum percentage of deliberate fires increase with increasing fire frequency, yield a net increase in the average reported value.

Illawarra: Two postcodes in this region experienced in excess of 500 fires in five years, with a further seven recording 200 to 499 fires. However, a high incidence of fires was evident across most parts of the region, with 14 of the 17 postcodes recording a fire experiencing more than 100 fires in five years (Figure 66).

The Illawarra region was characterised by a high number and high proportion of deliberate fires. Three postcodes recorded more than 200 deliberate fires, and a further six postcodes experienced more than 100 to 200 deliberate fires. Deliberate fires accounted for 47 percent of all fires in the Illawarra region, although locally (four postcodes) the rate was 70 to 80 percent (Figure 66). While there was moderately strong correlation between total fire number and the numbers of deliberately lit fires (r=.86) for postcodes in the region, the highest percentage of deliberate fires was not always observed in postcodes with the highest total fire numbers, suggesting that factors other than deliberate lighting played a role in the increased prevalence of vegetation fires in some Illawarra postcodes.

South Coast: Only one postcode, in the Shoalhaven–Part A SLA, experienced 200 to 500 fires in five years; another recorded between 100 and 200 fires (Shoalhaven–Part B SLA). These two major urban centres accounted for 49 and 17 percent of the fires the NSWFB attended in the South Coast region, respectively.

The percentage of deliberate fires in the South Coast region was low (16%), a reflection of the fact that causal attributions were made in a less than one-third of cases. One postcode in the Shoalhaven–Part A SLA accounted for two-thirds of all recorded deliberate fires in the South Coast region.

Hunter: Four postcodes in this region recorded in excess of 500 fires in total in five years, including two postcodes each within the Lake Macquarie and Cessnock SLAs. The majority of all fires in the Hunter region occurred in these two SLAs (Figure 67). A further 12 postcodes in the Hunter region recorded 200 to 499 fires, but just three had 100 to 199 fires in five years. Although high numbers of fires were observed across parts of this region, 32 postcodes observed less than 100 fires in five years.

Both postcodes in the Lake Macquarie region that recorded in excess of 500 fires also experienced in excess of 400 deliberate fires in five years, with half of all fires in the Lake Macquarie SLA being deliberately lit (Figure 67). A further six postcodes in the Hunter region experienced 100 to 300 deliberate fires in five years. However, this likely markedly underestimated the significance of deliberate fires in the Hunter region, as cause of fires was unknown in up to 40 to 80 percent of cases. For example, the cause of 441 out 568 fires (78%) in one postcode was unknown.

Central Coast: Nine of the 11 postcodes in the Central Coast region that recorded a fire recorded in excess of 95 fires in five years. Of these, one (in the Gosford SLA) had greater than 500, five that had 200 to 500 and two recorded 100 to 199 fires.

The incidence of deliberate lighting in the Central Coast region was also high. Two postcodes documented greater than 200 deliberate fires (one each in the Gosford and Wyong SLAs) and four that experienced 100 to 200 deliberate fires. Forty-five percent of fires in the region were recorded as resulting from deliberate causes, and typically 30 to 50 percent of fires in any one postcode in the Central Coast region were listed as deliberate. Nevertheless, the rate locally (in the Wyong SLA) reached 79 percent. The latter was observed in a postcode with among the lowest rates of unknown attributions (7%). Given that the cause of 30 to 60 percent of fires in most postcodes was unknown, the actual percentage of deliberate fires on the Central Coast may be higher than the 30 to 50 percent indicated above.

North Coast: One postcode in the Kempsey SLA recorded in excess of 1,000 fires in five years (Figure 68), having among the highest number of fires outside the Sydney region. This is consistent with the high numbers of fires reported by the NSWRFS in the same area. A further five postcodes in the North Coast region recorded 200 to 499 fires, and three experienced 100 to 199 fires.

Eighty percent of all fires in the Kempsey SLA were deliberate, and this SLA accounted for 60 percent of deliberate fires reported for the North Coast region. A high percentage of deliberate fires (48%) also occurred in the Port Stephens SLA, whereas the Hastings, Greater Taree and Nambucca SLAs all had comparatively high numbers of accidental fires. The proportion of unknown causes was also highly variable across the region.

Northern Rivers: Only one postcode in the Northern Rivers region recorded greater than 500 fires in five years (Figure 69). This occurred in the Coffs Harbour–Part B SLA, in the southern portion of the region, bordering the North Coast region. The level of causal attribution and the dominant cause of fires were highly variable across the Northern Rivers. Both the Coffs Harbour–Part B and the Tweed–Part A SLAs, areas that document the highest incidence of fires, recorded a high number of accidental fires, a small proportion of deliberate fires, and had a high percentage of fires of unknown causes. The highest percentage of deliberate fires occurred in the Richmond Valley (Pt A; 65%) and Tweed (Pt B; 53%) SLAs.

Blue Mountains: Two postcodes in the Blue Mountains region recorded 200 fires in five years; a further two experienced 100 to 200 fires. Deliberate fires typically constituted 20 to 30 percent of fires in a given postcode, but two postcodes recorded rates as high as 60 percent. Although no postcode in the Blue Mountains region recorded more than 80 deliberate fires, there were high levels of unknown attributions in many postcodes.

New England–North West: Three postcodes in this region recorded in excess of 500 fires in total in five years; one postcode (Moree Plains SLA) recorded in excess of 1,200 fires. This was among the highest number of vegetation fires recorded in a single postcode in the state. The NSWRFS also documented a high incidence of fires in this area. A further two postcodes, in the Armidale Dumaresq–City and Tamworth SLAs, recorded greater than 500 fires.

More than 500 deliberate fires occurred at one postcode in the Moree Plains SLA; and more than 300 occurred in one postcode in the Tamworth SLA. Approximately 50 to 60 percent of all fires in these two regions were deliberate in origin. In contrast, 3.5 percent of fires in the Armidale Dumaresq–City SLA were deliberate; a reflection of the low levels of causal attribution in that area (approximately 10%).

Explorer Country: Only one postcode, in the Dubbo–Part A SLA, recorded in excess of 500 fires in five years. The Orange and Bathurst SLAs recorded 200 to 300 fires in the five-year period, and Parkes and Wellington SLAs recorded 100 to 200 fires. The Dubbo–Part A SLA recorded in excess of 100 deliberate fires (n=251); 42 percent of fires in that location were deliberately lit. The highest percentage of deliberate fires was documented for the Wellington SLA (72%).

Capital Country: Only two postcodes in this region recorded in excess of 100 fires; Wingecarribee and Mulwaree SLAs. However, in both cases the number of fires did not exceed 130 in five years. Overall, the number of deliberate fires in Capital Country was low. However, the cause of one-third to three-quarters of all fires in the postcode was listed as unknown.

Riverina: Thirty-eight percent of all fires in the Riverina occurred in one Wagga Wagga–Part A SLA postcode. A further 29 percent occurred in one Griffith SLA postcode. Both postcodes recorded 400 to 600 fires in total. Deliberate causes accounted for 31 and 58 percent of fires in these two postcodes, respectively. These were the only two postcodes in the Riverina where the number of deliberate fires exceeded 100.

The Murray: Albury was the only SLA in the Murray region to record more than 400 fires, with 39 percent of fires in this SLA being deliberately lit. More than 100 fires were also recorded in the Deniliquin SLA; 21 percent being deliberate lit with the cause of 45 percent being unknown.

Outback: The NSWFB attended more than 500 fires in the Bourke SLA, of which approximately 95 percent were deliberately lit. High rates of deliberate fires (64%) were also recorded in the Brewarrina SLA. The NSWFB attended in excess of 500 and in excess of 100 deliberate fires in the Bourke and Brewarrina SLAs, respectively. More than 200 fires in total occurred in the Broken Hill postcode. Of these only one-fifth were deliberately lit but the cause of approximately 60 percent of fires in that centre was unknown.

Non-deliberate child fires: There was a strong overlap between locations that recorded a high number of non-deliberate child fires, and those that recorded a high number of fires generally. Notably, the number of non-deliberate child fires is moderately strongly correlated with the total number of fires within each SSD, SLA (r=.93) and postcode (r=.89).

Twenty-two postcodes recorded in excess of 100 fires started by children (non-deliberately) over a five-year period; 11 occurred in the Sydney region, three postcodes each from the Outer Western Sydney, Outer South Western and Fairfield–Liverpool SSD, and two from the Blacktown SSD. Notably, two postcodes recorded in excess of 100 child fires per year; these were in the Outer South Western Sydney and Blacktown SSDs. There were 130 postcodes (26% of postcodes recording a fire) where non-deliberate child fires contributed to 15 percent or more fires in that postcode – higher than the state average – but the rates were commonly much higher (up to 40%) in those postcodes recording in excess of 20 non-deliberate child fires per year. Notably, 47 postcodes across NSW (approximately 10% of all postcodes recording a fire) that recorded non-deliberate child fires accounted for at least one-quarter of all fires in the postcode.

The Campbelltown SLA was the only SLA to record an average of more than 200 non-deliberate child fires per year. Between 100 and 200 fires per year were also recorded in the Penrith, Blacktown South, Liverpool, and Wollongong SLAs. The highest numbers of fires within individual SLA outside of the Sydney region included:

- 20–40 child fires per SLA per year: Wollongong, Lake Macquarie, Moree Plains, Wyong.
- 10–19 child fires per SLA per year: Inverell, Newcastle–Remainder, Cessnock, Wagga Wagga, Coffs Harbour, Greater Taree, Dubbo and Hastings–Part A SLAs.

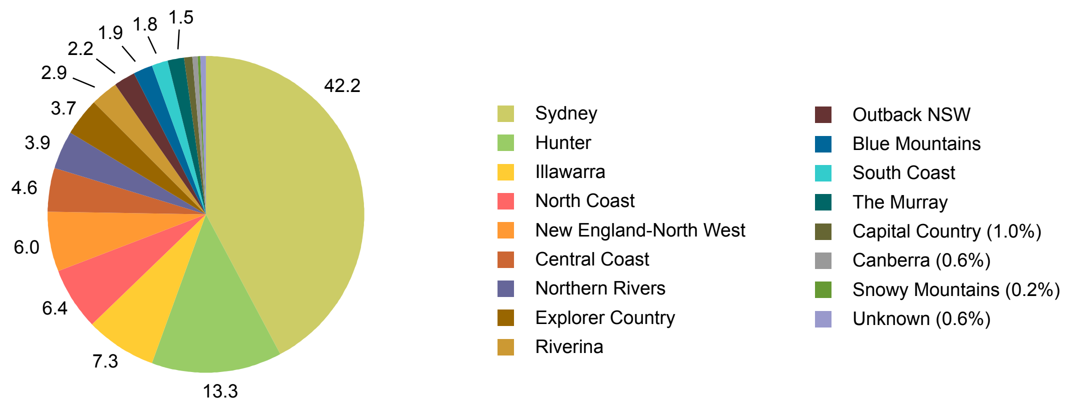
Table 4: Distribution of fires within postcodes within SSDs in the Sydney region

	Outer South Western		Fairfield–Liverpool		Blacktown		Outer Western		Canterbury–Bankstown		Central Western		St George–Sutherland		Central Northern		Northern Beaches		Inner Sydney		Eastern Suburbs		Lower Northern		Inner Western	
No. fires	5,129		3,979		3,808		3,182		1,315		1,171		1,145		1,104		687		648		549		538		253	
No. of postcodes	15		10		10		12		18		13		23		26		19		25		16		18		13	
	No.[a]	**%**	**No.[b]**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
TF≥500	3	76	2	53	2	59	2	51																		
200–499	2	11	4	33	4	30	3	35			1	19									1	41				
100–199	3	9	3	11	2	10	2	10	2	24	4	42	3	44	2	26	1	15								
75–99	2	3	1	2			1	3	8	53	3	22	1	8	2	17	3	37			1	15			1	31
50–74	1	1							1	4	1	4	2	11	3	17			3	29	1	9	3	37		
25–49					1	1	1	1	6	17	4	13	8	27	8	28	6	32	6	39	3	16	6	40	3	34
<25	4	0.2			1	0.1	3	1	1	2			9	11	11	13	9	16	16	33	10	19	9	23	9	36
Deliberate fires																										
No. deliberate	2,208	1,558	1,623	1,197	438	393	326	341	186	126	118	110	63													
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
>200	3	78	2	58	2	60	3	73																		
100–199	2	12	2	21	2	18	1	9																		
75–99	1	4	1	5	4	21	1	8																		
50–74	2	5	2	8			1	5	1	15	2	29	2	37	1	17										
25–49			3	9			1	4	7	54	5	48	1	13	3	29	2	35			2	56				
<25	3	1			2	1		2	10	31	6	23	19	51	21	54	17	65	23	100	11	44	18	100	12	100

a: no. refers to the number of postcodes with total fires/deliberate fires in the specified range

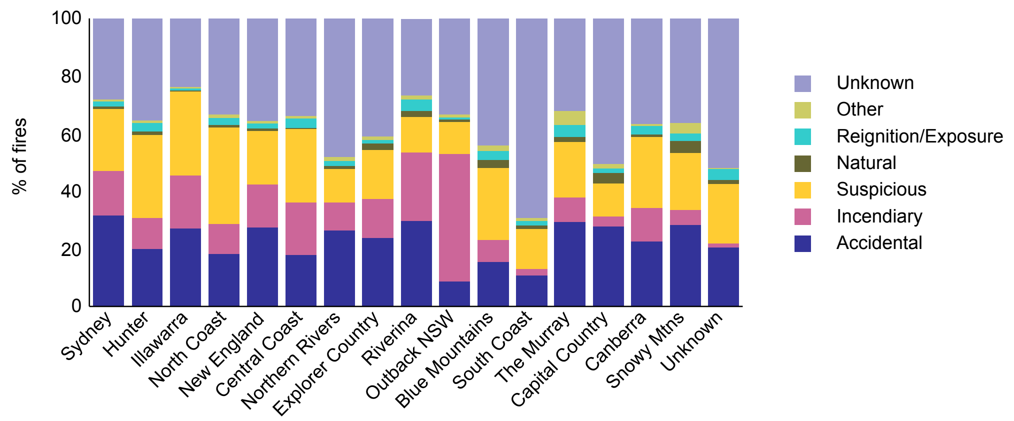
b: % refers to the proportion of all fires in the SSD that occurred within suburbs within the specified range

Figure 56: All vegetation fires, by region (percent)



Source: NSWFB 1997–98 to 2001–02 [computer file]

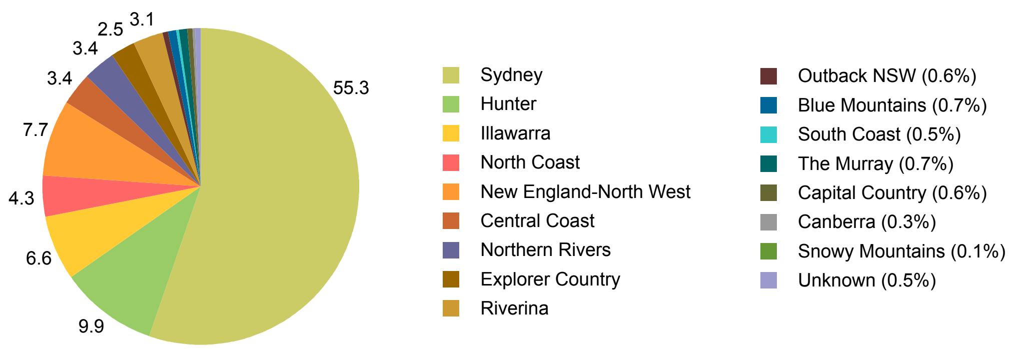
Figure 57: Region[a], by cause (percent)



a: Regions arranged in order of decreasing total fire number

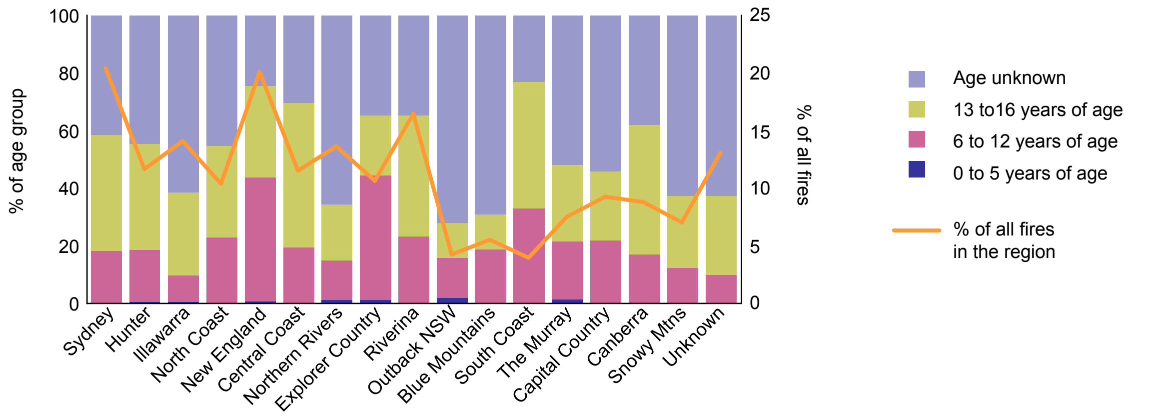
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 58: Non-deliberate child fires, by region (percent)



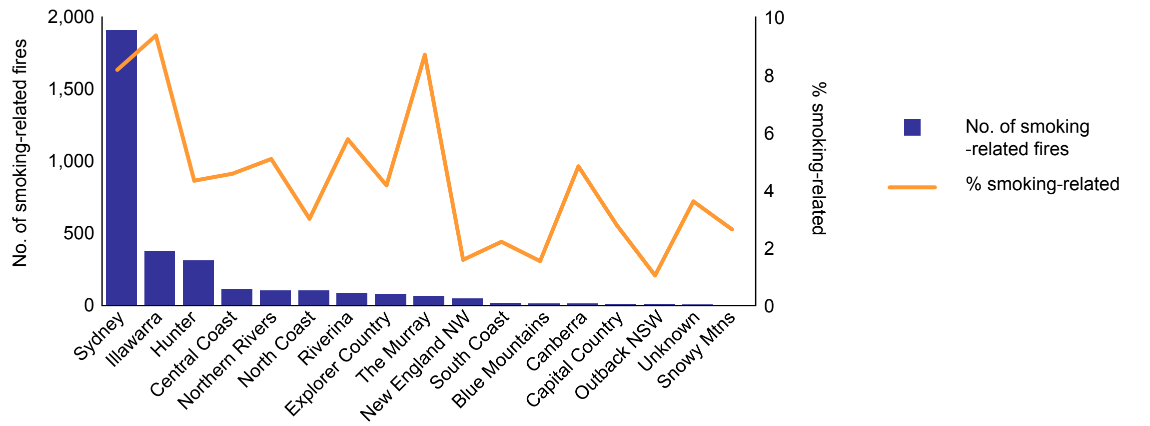
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 59: Non-deliberate child fires, by child's age for each region



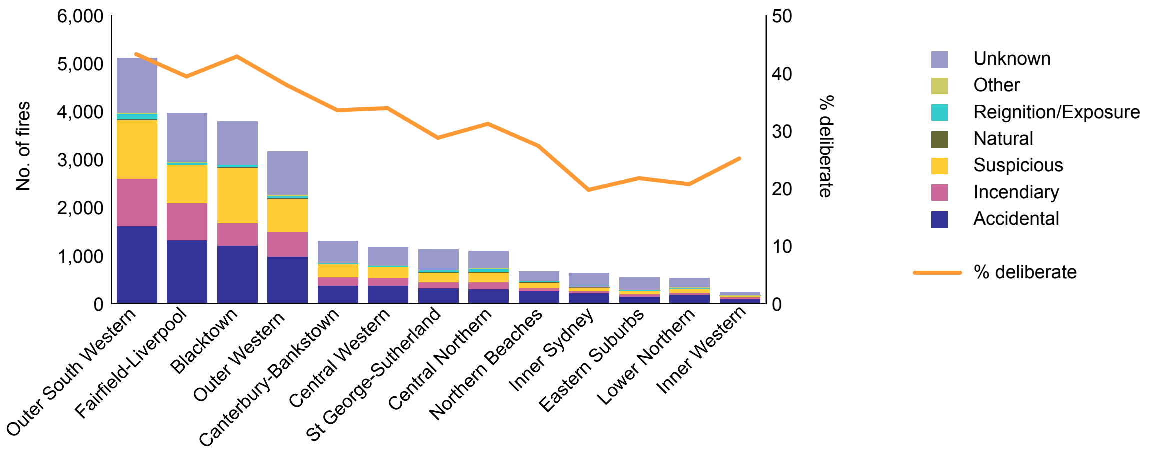
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 60: Smoking-related fires, by region



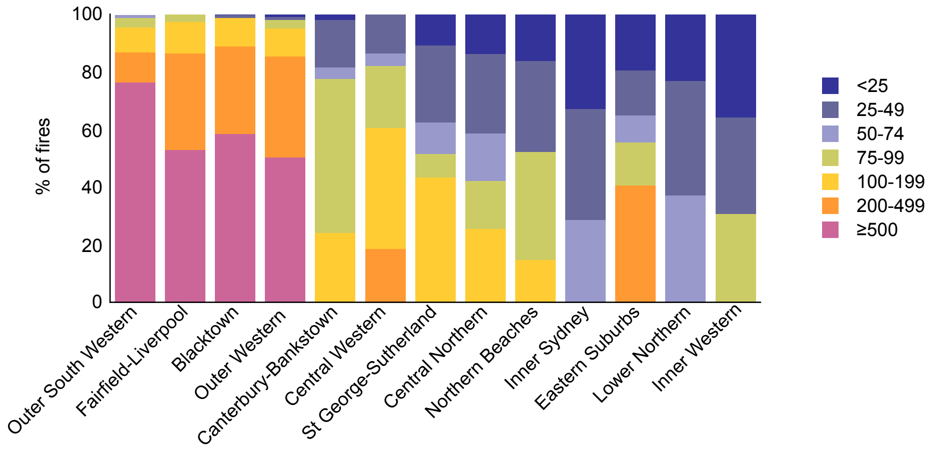
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 61: Cause of fire, by SSD in the Sydney region



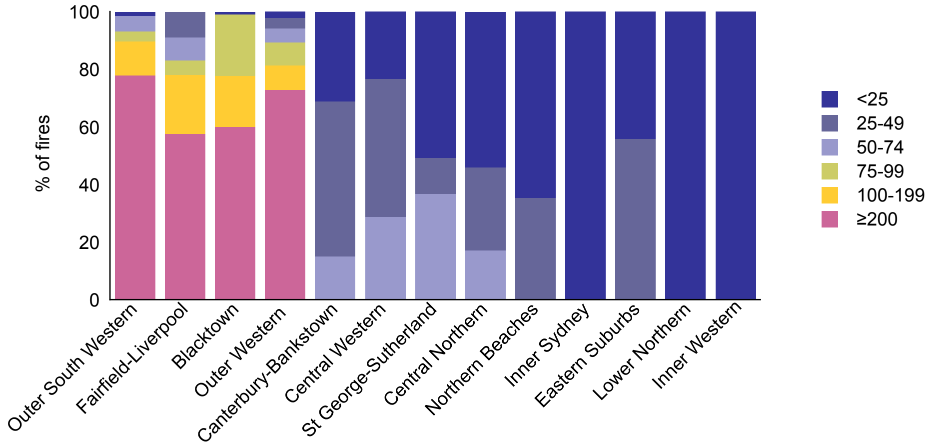
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 62: Sydney region, distribution of all fires within postcodes in each SSD (percent)



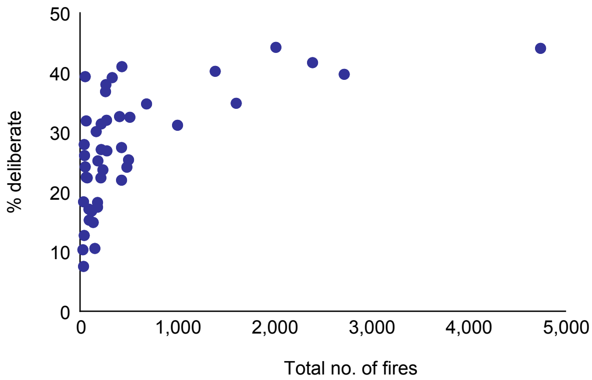
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 63: Sydney region, distribution of deliberate fires within postcodes in each SSD (percent)



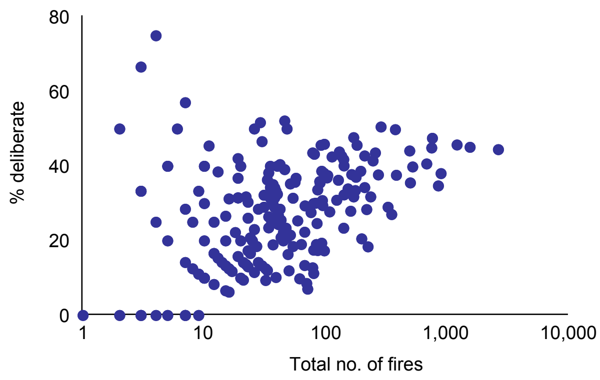
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 64: Percentage deliberate and total fire number, by SLA



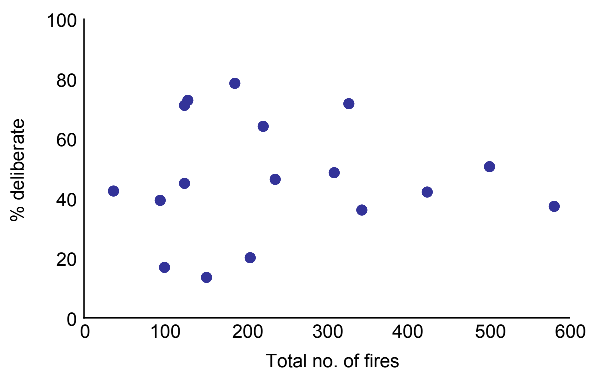
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 65: Percentage deliberate and total fire number, by postcode



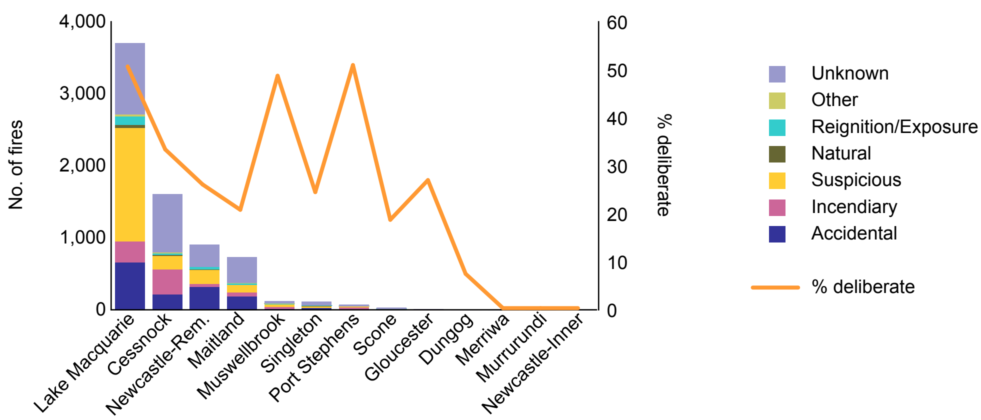
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 66: Percentage deliberate and total fire number by postcode in the Illawarra region



Source: NSWFB 1997–98 to 2001–02 [computer file]

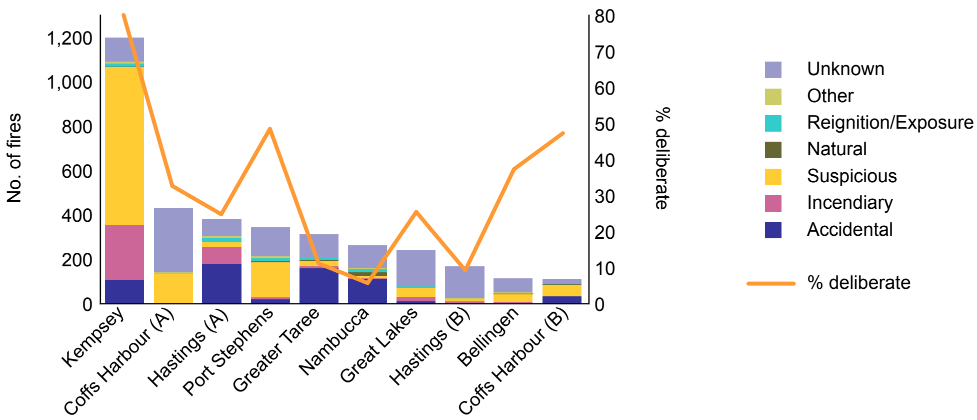
Figure 67: Cause, by SLA in the Hunter region[a]



a: Newcastle-Rem. = Newcastle-Remainder

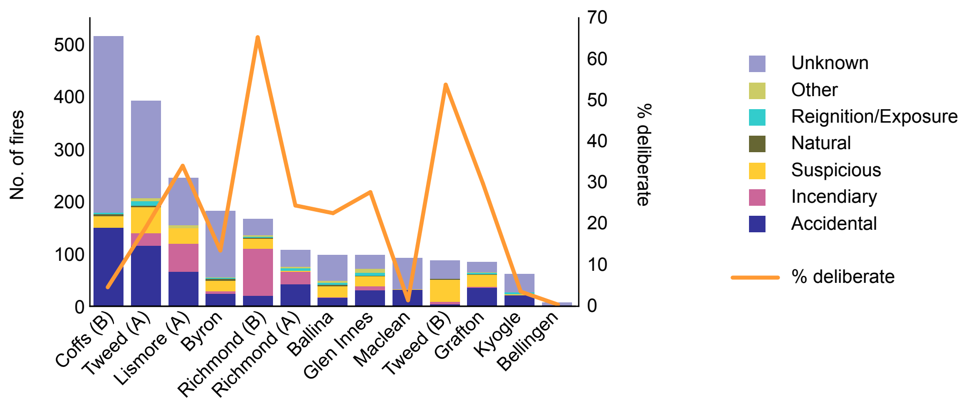
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 68: Cause, by SLA in the North Coast region



Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 69: Cause, by SLA in the Northern Rivers region[a]



a: Coffs = Coffs Harbour; Richmond = Richmond Valley

Source: NSWFB 1997–98 to 2001–02 [computer file]

Complex

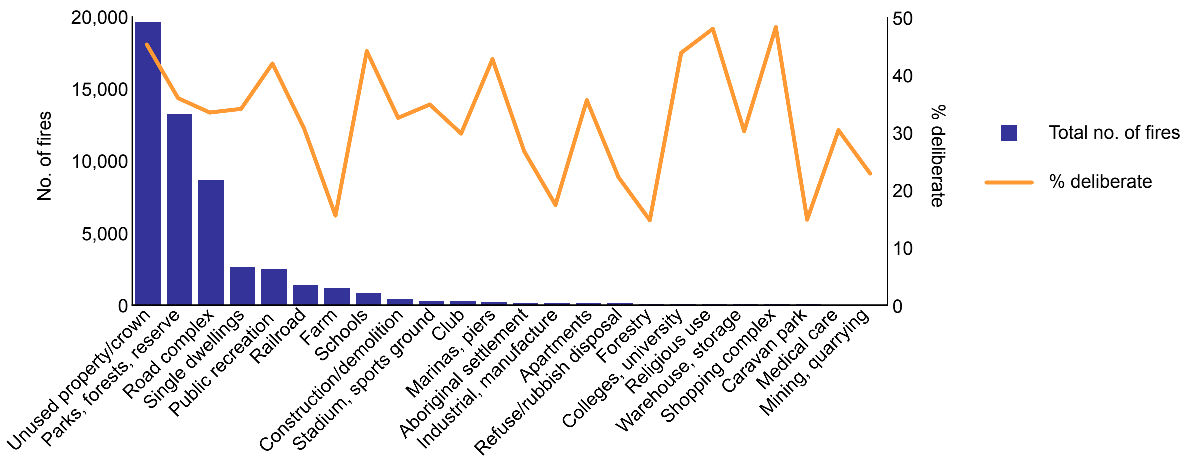
The majority of vegetation fires the NSWFB attended occurred on unused property or Crown land (35%). Other locations where fire frequently occurred included parks, forests and reserves (23%), road complexes (5%) and public recreation complexes (5%; Figure 70).

In those complexes experiencing an average of 10 or more fires per year, the percentage of deliberate fires was highest at shopping centres and religious buildings (48%), unused property or Crown land (45%), schools, colleges and universities (44%). The proportion of deliberate fires in complexes experiencing an average of 10 or more fires per year was lowest (15 to 17%) for forestry complexes, caravan parks, farms and industrial/manufacturing areas.

Most non-deliberate child fires also occurred on unused property or Crown land, parks, forests, reserves, and near road complexes (Figure 71). Non-deliberate child fires accounted for the highest proportion of fires in Aboriginal settlements (20%), at schools (17%), in parks, forests, reserves, at marinas/piers, and on unused property and Crown land (16%), for complexes experiencing an average of six or more child fires per year. The diversity of localities where children lit fires and the proportion of fires occurring near road complexes increased with age (Figure 71). This was to some degree paralleled by a decrease in the number of fires occurring at single dwellings.

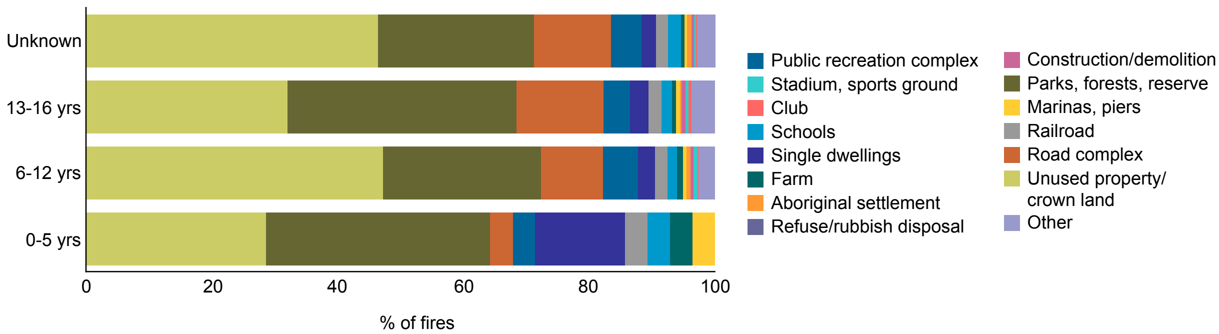
Not surprisingly, 40 percent of all fires resulting from abandoned and discarded materials were associated with road complexes (Figure 72). Another 20 percent occurred in parks, forests and reserves, and 16 percent were on unused property or Crown land.

Figure 70: Total fire number and percent deliberate, by complex type



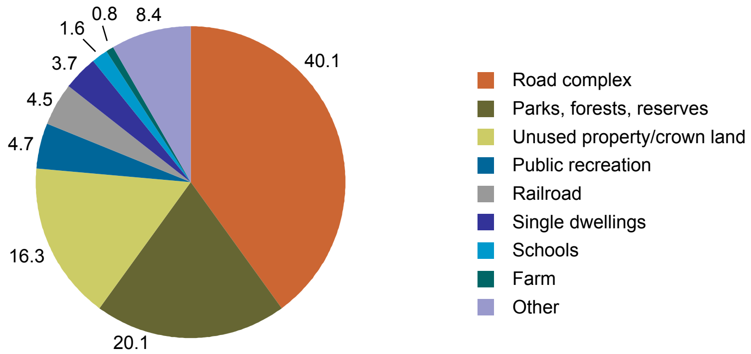
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 71: Non-deliberate child fires, by child's age and location (percent)



Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 72: Discarded or abandoned materials, by complex type (percent)



Source: NSWFB 1999–2000 to 2003–04 [computer file]

Timing

The timing of fires is examined by week of the year, day of the week and time of the day.

Week of the year

NSWFB-attended fires peaked during two distinct intervals, from mid August to mid November (late winter and spring) and in mid-December–January, coincident with the Christmas school holidays. The latter began at week 49 and ended at week 4 or 5, with the maximum occurring during week 52 (Figure 73). This dual-spiked pattern was evident for all human-caused fires, including incendiary and suspicious fires.

This dual-peaked pattern is similar to that observed for the NSWRFS data. The most notable discrepancy relates to relative size differences in the August–October and December–January peaks, with the latter being markedly greater for the NSWFB than for the NSWRFS. These differences may pertain to differences in the seasons analysed, differences between the principal causes of fires in rural and urban areas (higher contributions of child and smoking-related fires, as noted above), as well as differences in relative contributions from regions with differing patterns of fire regimes (for example, the higher proportion of fires in the Sydney region will lead to more December–January fires relative to August–October fires, see below).

Seasonal trends: As noted for the NSWRFS data, the timing of fires by week of the year varied markedly between seasons. In 1997–98, low spring rainfall associated with an El Niño event resulted in high fire numbers early in the season. Although the number of fires each week dropped slightly as the season progressed, the numbers of fires remained elevated until the middle of April (Figure 74). In contrast, during 1998–99, the number of fires remained low until early to middle October, peaked in early January, before rapidly decreasing. In 1999–2000, the number of fires remained low until late December, climbed through January and February before rapidly decreasing. In 2000–01 two significant spikes in activity occurred, coincident with the August–November and December–January peaks respectively. In 2001–02 fire numbers remained high from mid July through to mid January, with three spikes in activity at weeks 34, 44 and 52. The latter precisely coincided with the spikes in the NSWRFS data.

These results highlight the highly unpredictable nature of the bushfire season in NSW, ultimately a reflection of the lack of conformity in the amount and timing of spring and summer rainfall (Figure 25 to Figure 27). Note that August–October peaks were specific to those years characterised by a lack of adequate winter and/or spring rainfall, whereas a spike in mid to late summer fires are typical of most seasons. It is the number of the August to October fires that was the largest single contributor to differences in the number of fires observed between seasons in the NSWFB data. Interestingly, the most destructive December–January fires occurred in years where high numbers of fires were recorded in August–October.

Regional trends: As observed for the NSWRFS data, the timing of fires varied between regions. There were strong similarities between the time of the year fires occurred in the Sydney (Figure 75), Hunter (Figure 76), Central Coast (Figure 77), and Illawarra (Figure 78) regions, and it is this pattern that dominates the trend observed for the NSWFB data generally. Nevertheless, subtle differences were evident between these regions. Increased numbers of fires were evident in December–January in most seasons in the Sydney region, but were most pronounced during 2001–02 (Figure 75). In that season 344 fires occurred during the last week of 2001. Twenty-two percent of those were identified as being either incendiary or suspicious in origin. In contrast, the Central Coast and Hunter regions recorded several short but intense spikes in fire numbers throughout 2000–01 and 2001–02. The number of fires during these weeks markedly exceeded that observed in any other years. The pattern for the Illawarra most closely resembled that observed for the Sydney region, although it is noted that the increase in fire numbers that occurred during week 52 of 2001 (Christmas–New Year fires of 2001) was proportionally greater in the Illawarra region than in the Sydney region. Disturbingly, approximately 45 percent of fires during that week were likely to have been deliberately lit but this value is consistent with the high proportion of deliberate fires recorded in the Illawarra generally. A large spike in fire numbers was also observed in the South Coast region during December 2001, but an increase in fire numbers during late December–January was a feature common to most seasons on the South Coast.

The Blue Mountains region not only recorded a lower number of fires but these have a markedly different distribution from those of the neighbouring Sydney region. The highest number of fires typically occurred in the first half of the season, before the Christmas–New Year period (Figure 79). However, a marked spike in fire numbers occurred during week 52 of 2001. Approximately one-quarter of all fires during that week resulted from reignition or exposure with the cause of a further half of fires being unknown.

In contrast to the patterns outlined above, the majority of fires in the Murray (Figure 80) and Riverina regions occur around the December–January period every year. To a lesser degree this also occurred in the Explorer Country, although there is greater variability between seasons in that region. The Capital Country most consistently experienced the greatest number of fires around Christmas, but high number of fires (but low overall) also occurred through late winter to early autumn.

The number of fires in the Northern Rivers (Figure 81) and North Coast regions (Figure 82) was highest in the more adverse bushfire seasons. Most fires in these two regions occurred during late winter and spring, coincident with lower than normal rainfall during these periods (Figure 27). Nevertheless, higher than normal numbers of fires also occurred during December–January 2001–02, and to a lesser extent 2000–01 (principally the Northern Rivers region).

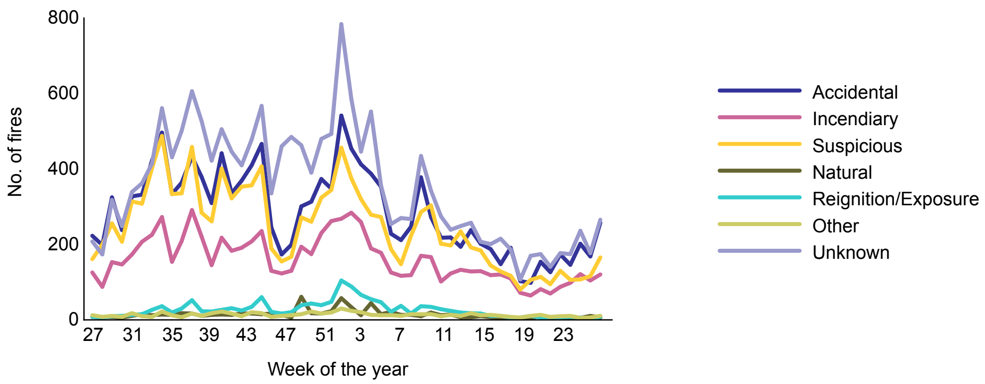
Fires in the Outback were less governed by seasonal trends. The greatest number of fires occurred in 2000–01, with spikes in deliberate fire activity occurring in early October, mid January and early March. Fires in the New England–North West did not follow a consistent seasonal pattern with increased fire numbers potentially occurring in any month of the year, and the pattern being highly variable from season to season.

Non-deliberate child fires: Overall, the distribution of non-deliberate child fires throughout the year parallels that observed for fires generally, but particularly the trend observed for the Sydney region. That is, the majority of fires occurred between mid August and mid November with an additional peak during the Christmas school holidays, and to a lesser extent in early autumn (Figure 83).

Some differences where noted between age groups. The pattern for 13 to 16 year olds paralleled that observed for fires generally. A similar trend was evident for fires started by children of unknown age. In contrast, non-deliberate fires started by children aged 6 to 12 years were more evenly spread throughout the year, although a greater prevalence of fires did occur during the bushfire season.

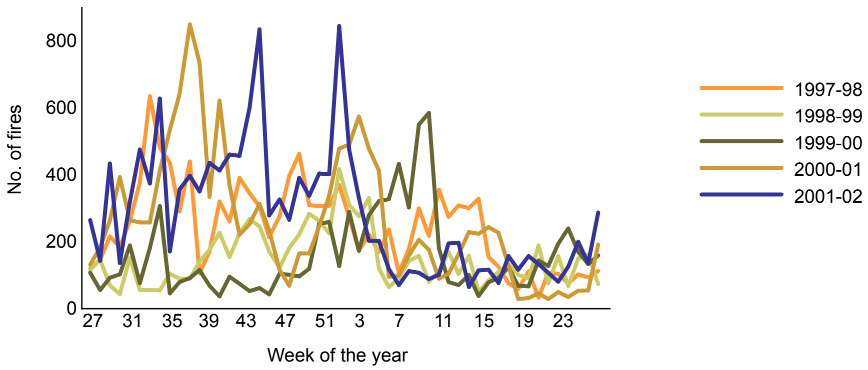
The timing of non-deliberate child fires strongly paralleled the general timing of fires within individual regions. For example, child fires in the Riverina principally occurred around Christmas–New Year, whereas child fires in the New England–North West region occurred throughout the year (Figure 84). However, some differences were noted. Overall, the number of fires attributed to children was lower during December–January than August–November. This differs from the general trend, and possibly not what might be expected for a school holiday period. However, child fires on the South Coast were most likely to occur over the Christmas–New Year period, being negligible during late winter and spring period, but this again differed from the general trend observed for the South Coast.

Figure 73: Week of the year, by cause (number)



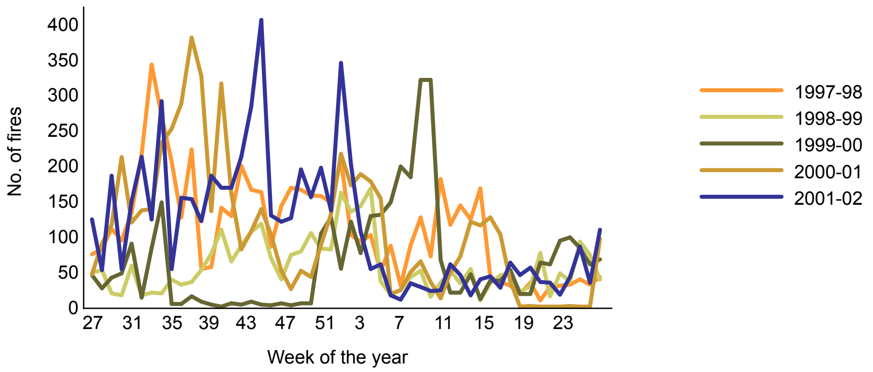
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 74: Week of the year, by year (number)



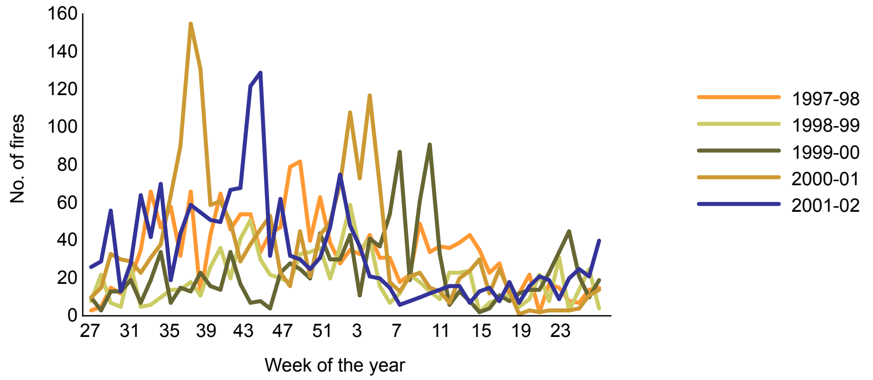
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 75: Week of year, by year for the Sydney region (number)



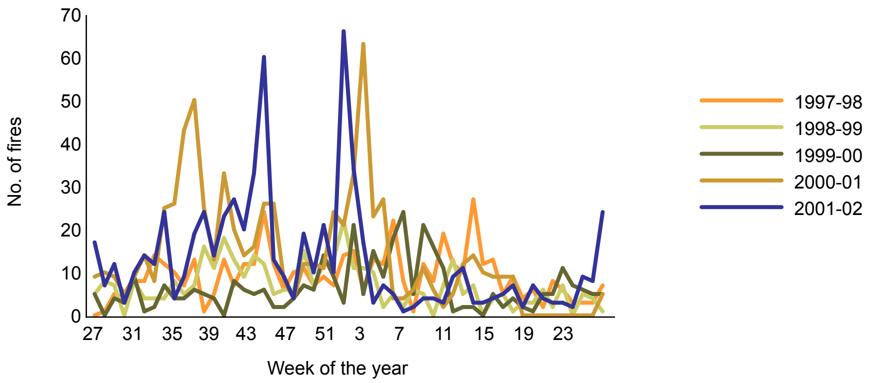
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 76: Week of year, by year for the Hunter Region (number)



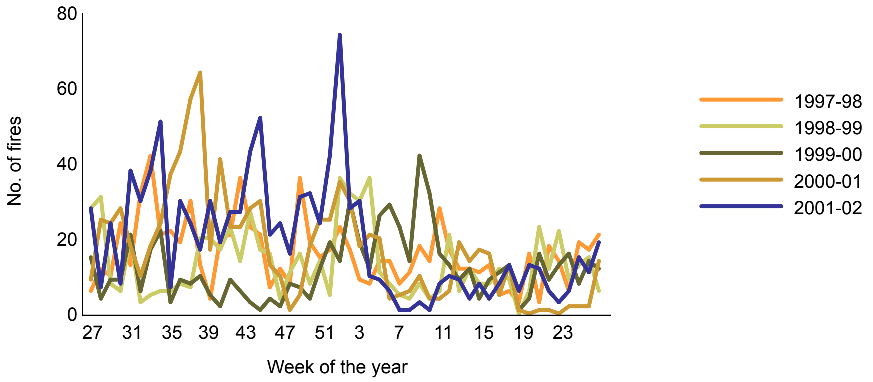
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 77: Week of year, by year for the Central Coast region (number)



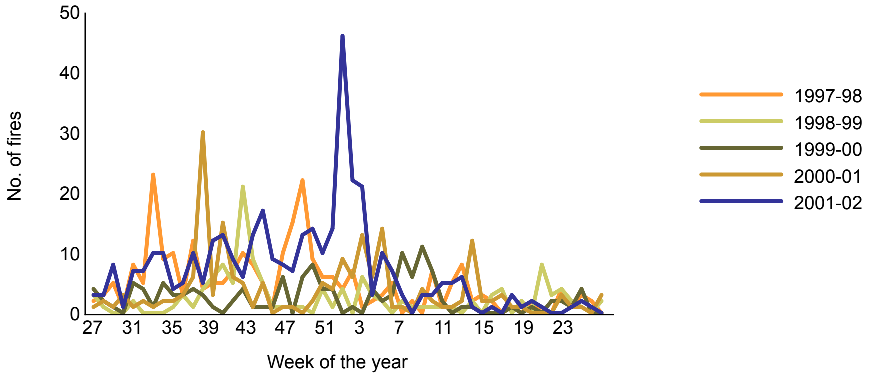
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 78: Week of year, by year for the Illawarra region (number)



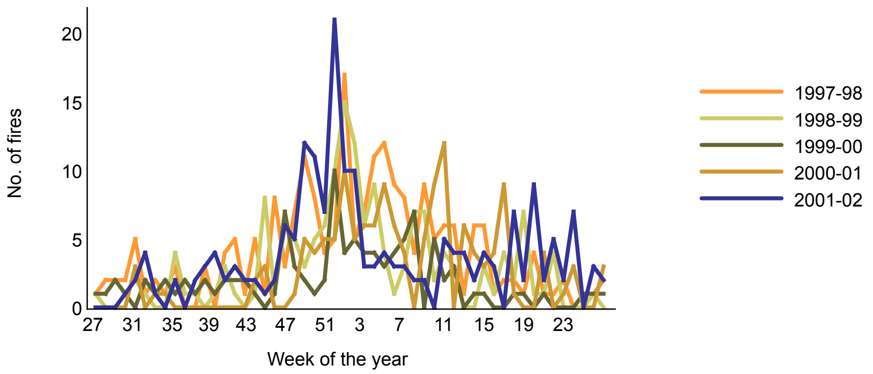
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 79: Week of year, by year for the Blue Mountains region (number)



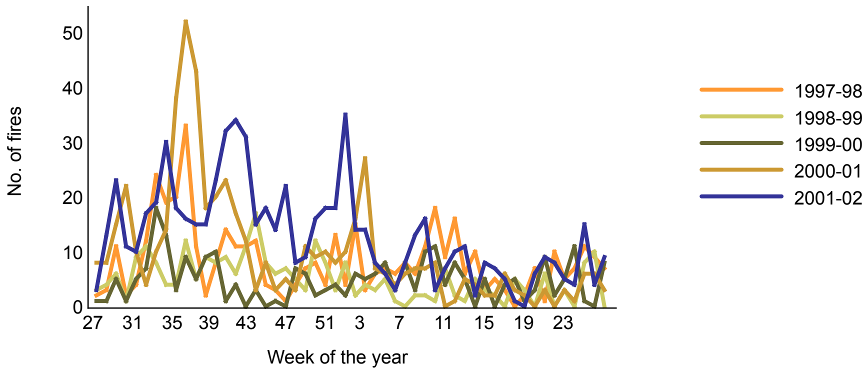
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 80: Week of year, by year for the Murray region (number)



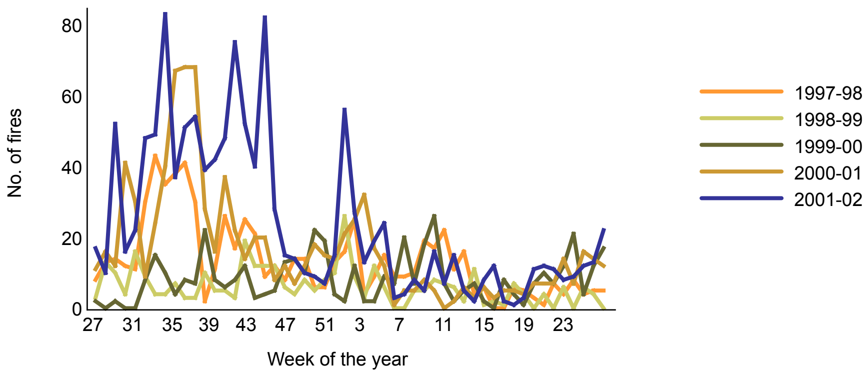
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 81: Week of year, by year for the Northern Rivers region (number)



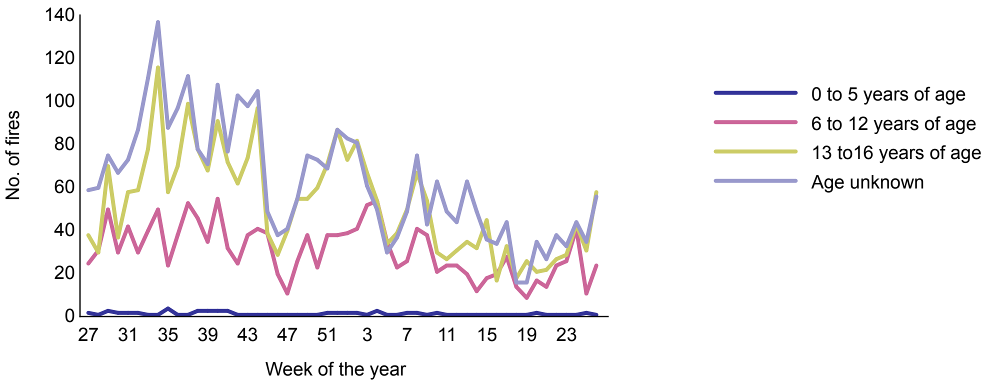
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 82: Week of year, by year for the North Coast region (number)



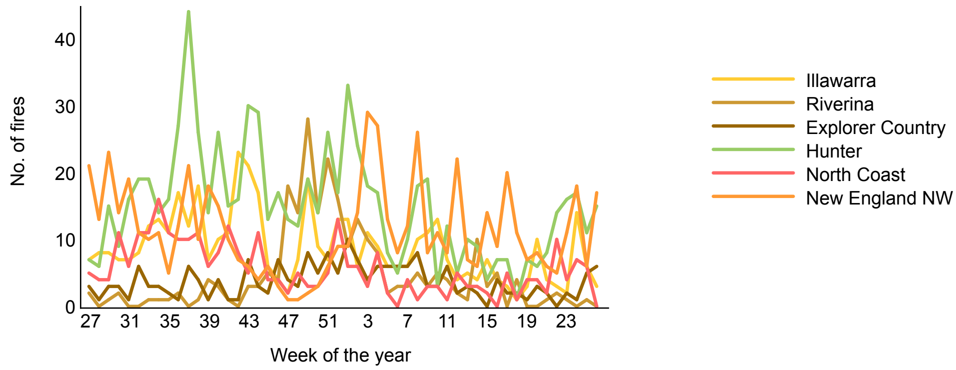
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 83: Non-deliberate child fires, by week of the year and age group (number)



Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 84: Non-deliberate child fires, by week of the year for selected regions (number)



Source: NSWFB 1997–98 to 2001–02 [computer file]

Day of the week

Overall, fires the NSWFB attended were 30 percent more likely to occur on Saturday and 28 percent more likely to occur on Sunday than on the average weekday. The tendency for increased number of fires on weekends was evident for all human-related causal categories (Figure 85). Incendiary fires were approximately 40 percent more likely to occur on Saturdays and Sundays relative to the weekday average. Suspicious fires were 29 to 32 percent more likely on Saturdays and Sundays. Similar values were evident for accidental fires (29 to 34%). Fires resulting from natural causes, reignition or exposure and other causes did not display any bias by day of the week.

All regions of NSW recorded higher numbers of fires on weekends relative to weekdays with the exception of the Snowy Mountains, but the extent of that increase was variable (Figure 86). For the majority of regions across NSW, fires were 30 to 40 percent more likely to occur on Saturday and Sunday relative to a weekday. However, in the Riverina region fires were 50 percent more likely on a Saturday or Sunday relative to a weekday. In the Capital Country and Outback regions 50 percent more fires occurred on Sunday but only 20 to 30 percent more occurred on Saturday, relative to the average weekday. Surprisingly, the proportion of weekend fires was among the lowest in the Sydney (23 and 27% respectively) and the Central Coast (16 and 25% respectively) regions; regions that overall experienced high numbers of fires. This is contrary to the trend observed in many other jurisdictions, where the strongest weekend bias occurred in those regions encompassing the major metropolitan centre.

Non-deliberate child fires were more likely to occur on weekends for all age groups except the children younger than six years old. Overall, fires started by children were 36 percent more likely to occur on Sunday and 42 percent more likely to occur on Saturday than during a weekday. This is similar to the trend observed generally.

Time of the day

The detection time of fires was available for 60 percent of NSWFB-attended fires. Overall, fire numbers peaked between 3 pm and 7 pm, and most typically within the 4 to 5 pm window (Figure 87). In contrast to observations from many other jurisdictions, there was no offset between the peak in deliberate and non-deliberate fires on a statewide basis. This reflects the observation that the peak in accidental fires is somewhat later for the NSWFB than for other jurisdictions.

Fires occurring between 6 pm and 6 am did not form a distinct night peak in the NSWFB data; rather there was a 'shoulder' on the daytime curve for times after 7 to 8 pm. This shoulder was greater for incendiary and suspicious fires than for accidental fires, consistent with observations elsewhere that a higher proportion of night-time fires result from deliberate causes. Approximately 33 percent of all recorded incendiary and suspicious fires occurred between 7 pm and 5 am, compared to a value of 26 percent for accidental fires. The rate of 31 percent for unknown fires is comparable to that observed for deliberate fires, suggesting that many fires of unknown cause may be deliberate in origin. The greatest proportion of deliberate NSWFB-attended night-time fires occurred on Friday night–Saturday morning and Saturday night–Sunday morning (Figure 88). This was most evident between midnight and 6 am.

The distribution of deliberate daytime fires also differed between the weekends and weekdays. Notably, the daytime peak on weekends was both higher and broader than for weekdays; the daytime peak on weekdays was skewed toward later times than its weekend counterpart with peak numbers occurring between 4 and 7 pm as opposed to 2 and 5 pm.

While the trends described above represent the dominant case, it is evident that the predominant timing of deliberate fires varied between regions (Figure 89 and Figure 90). For example, only 22 to 28 percent of fires in the Snowy Mountains, Hunter, North Coast, Northern Rivers, New England–North West and Central Coast regions occurred between 7 pm and 5 am. This compares to values of 31 to 34 percent for the Sydney, South Coast and Blue Mountains regions and 40 to 48 percent in the Illawarra, Capital Country, Murray, Riverina, and Explorer Country and Outback regions.

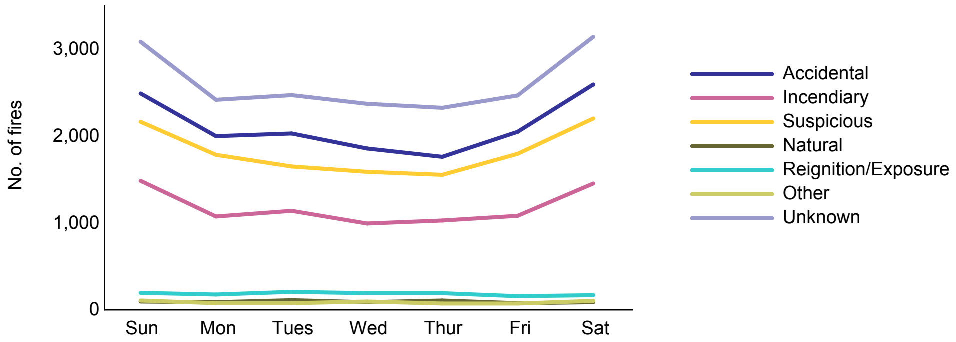
Although an increased number of deliberate fire were set between 7 pm and 5 am on Friday night–Saturday morning and Saturday night–Sunday morning in the Sydney region as a whole (Figure 91), this was not uniformly manifest across all districts within that region. Night-time fires were proportionally of greater significance in areas like the Central Western, Central Northern and Canterbury–Bankstown SSDs – areas characterised by lower fire numbers – than in the Fairfield–Liverpool, Outer South Western, Outer Western and Blacktown SSDs –areas in which there was a high incidence of fires overall (Figure 92). More specifically, only 27 percent of fires in the Outer South Western Sydney SSD occurred between 7 pm and 5 am. Comparatively smaller differences were evident between the numbers of fires on weekends and weekdays in that region (Figure 93). In contrast, 43 percent of fires the Canterbury–Bankstown region occurred between 7 pm and 5 am, but unlike the general trend for the Sydney region, night-time fires were common on most nights of the week except Tuesday and Wednesday nights.

Similarly, fires between 7 pm and 5 am were also common on most night of the week in the Illawarra region. Moreover, fires on Friday night–Saturday morning were more likely to occur earlier than on Saturday night–Sunday morning in the Illawarra region (Figure 94). Night-time fires in the Riverina also occurred on most nights of the week.

The disparity between these trends illustrates that general patterns of deliberate fires cannot necessarily be translated to individual cases and individual instances need to be evaluated to understand the types of factors underlying deliberate firesetting in each location.

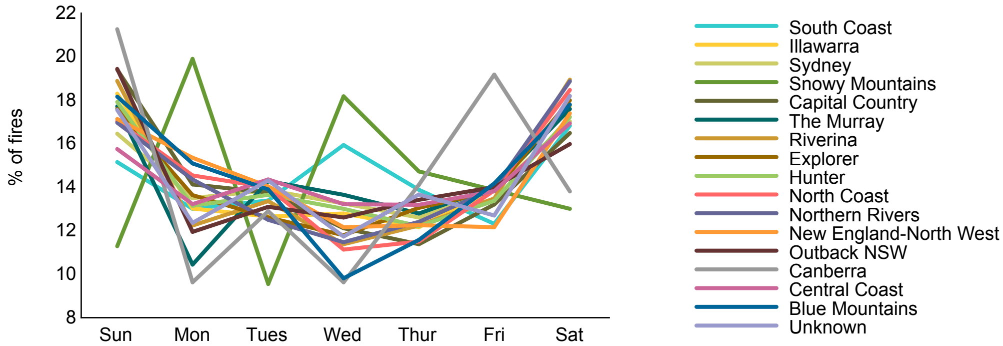
The majority of non-deliberate child fires occurred during the day, peaking between the hours of 3 and 6 pm, but there were clear disparities between the trends observed on weekdays and weekends (Figure 95). Non-deliberate child fires on weekdays peaked during a narrower interval that was somewhat later (3 to 7 pm) than on weekends. One-quarter of all fires attributed to children occurred between the hours of 7 pm and 5 am. Overall, there were strong parallels between many of the trends observed for non-deliberate child fires and those observed for deliberate fires. This may reflect the fact that the deliberate category includes malicious fires started by children less than 16 years of age. Not surprisingly, the proportion of night-time fires was greater for 13 to 16 year-olds (32%) than for 6 to 12 year-olds (15%; Figure 96), with more night-time fires occurring on Friday night–Saturday morning and Saturday night–Sunday morning.

Figure 85: Cause, by day of the week (number)



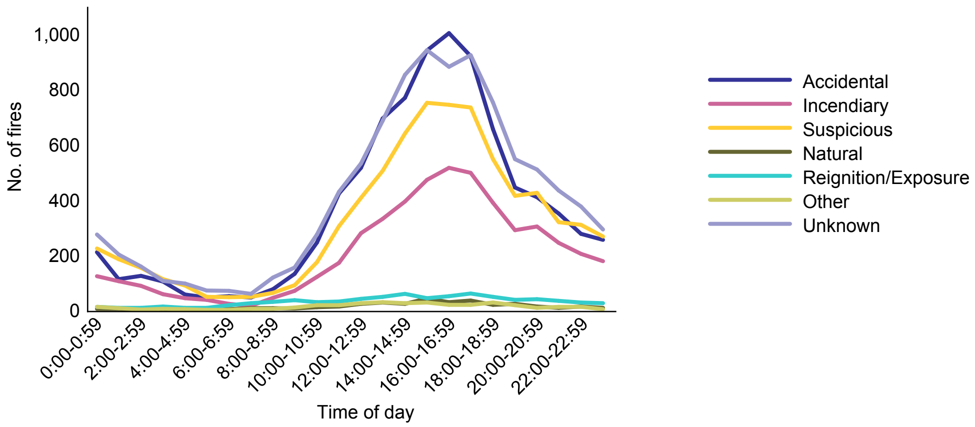
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 86: Fires in each region, by day of the week (percent)



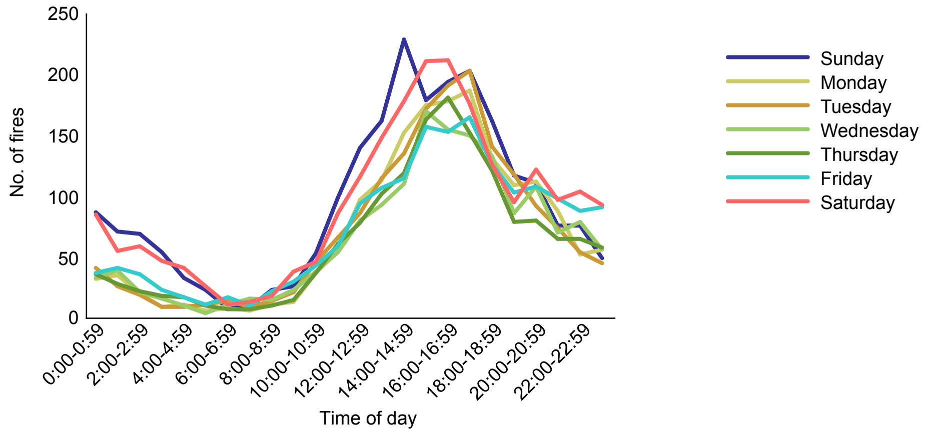
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 87: Time of day, by cause (number)



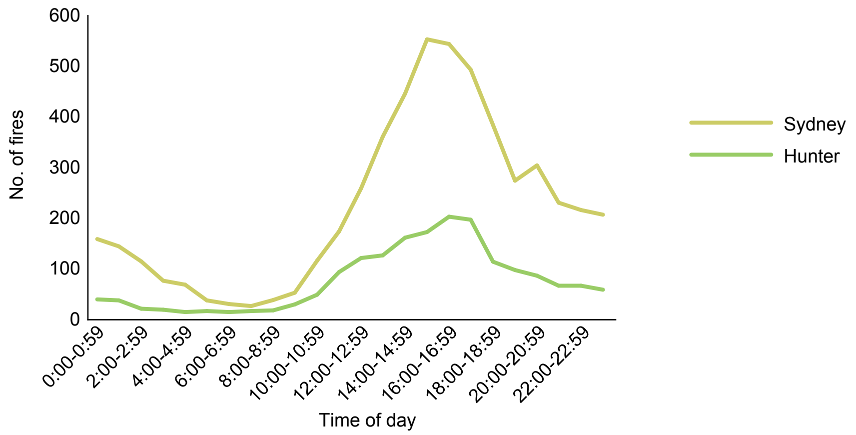
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 88: Deliberate fires, by time of the day and day of the week (number)



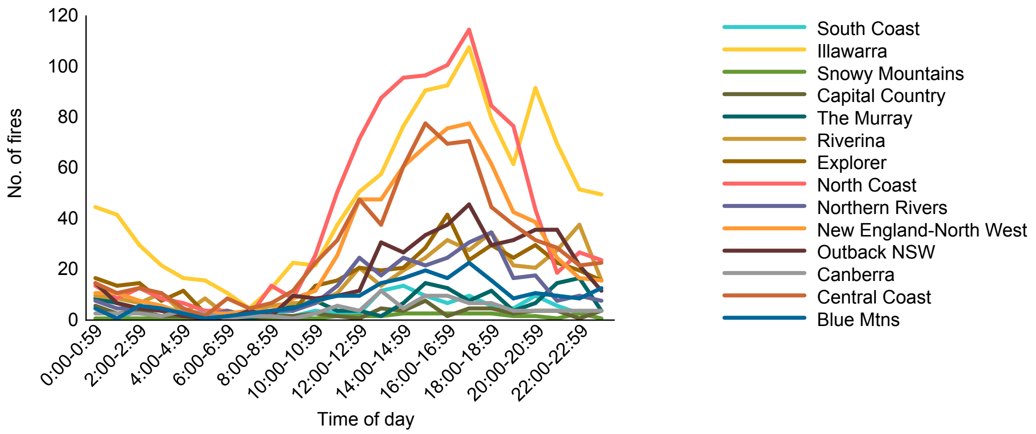
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 89: Deliberate fires, by time of day in the Sydney and Hunter regions (number)



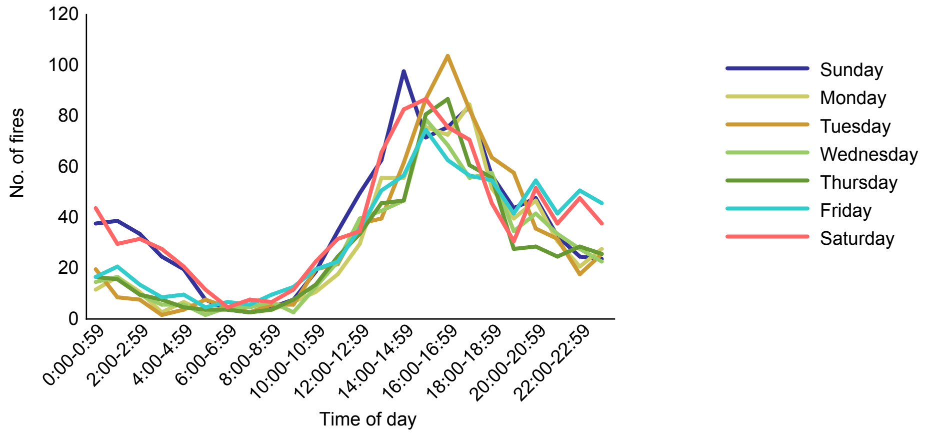
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 90: Deliberate fires, by time of day in other regions (number)



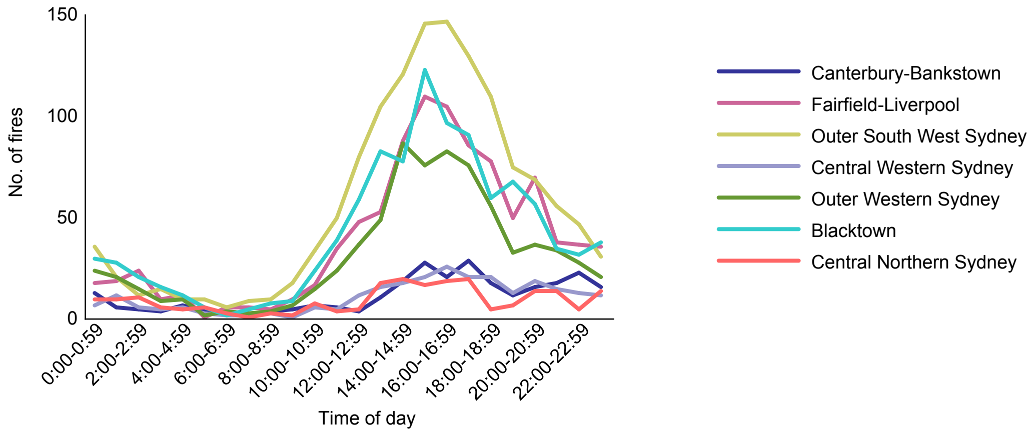
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 91: Deliberate fires, by time of day and day of the week for the Sydney region (number)



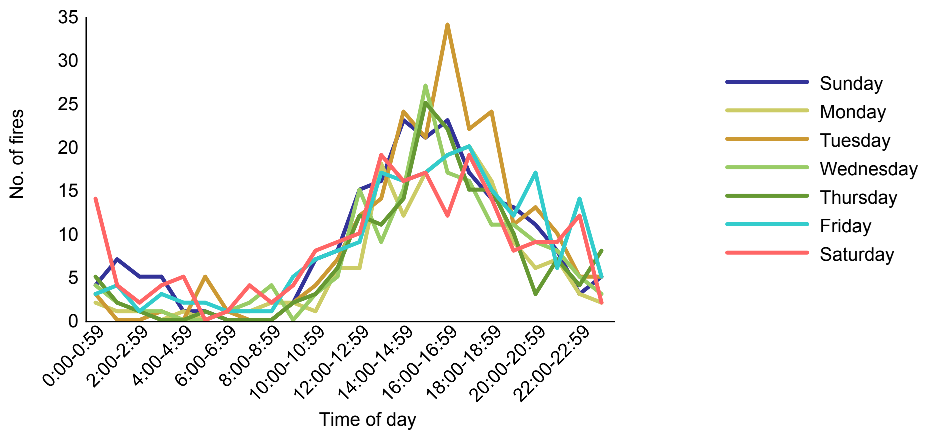
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 92: Deliberate fires, by time of day for selected Sydney SSDs (number)



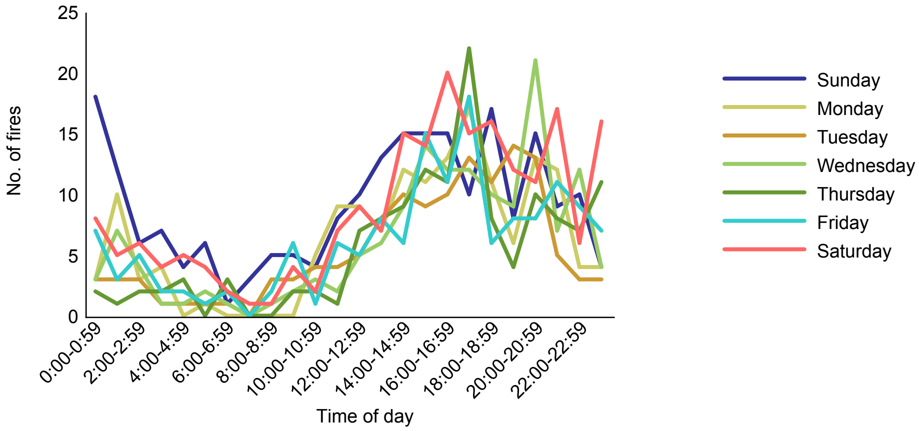
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 93: Deliberate fires, by time of day and day of the week for the Outer South Western SSD (number)



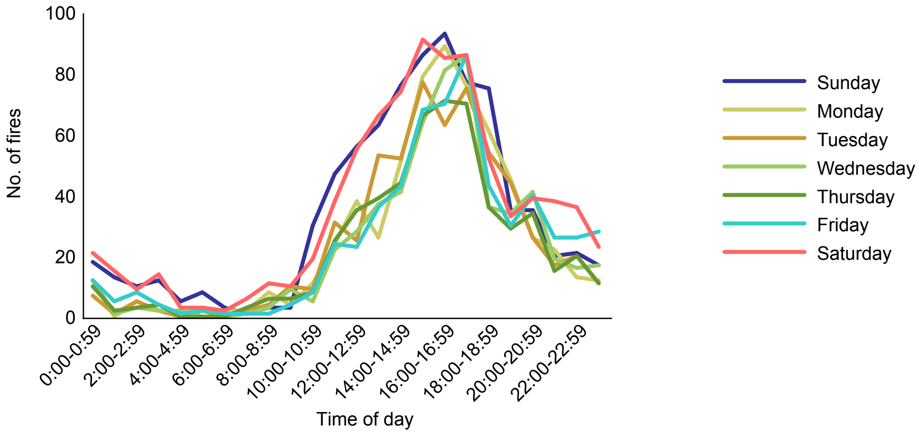
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 94: Deliberate fires, by time of day and day of the week for the Illawarra region (number)



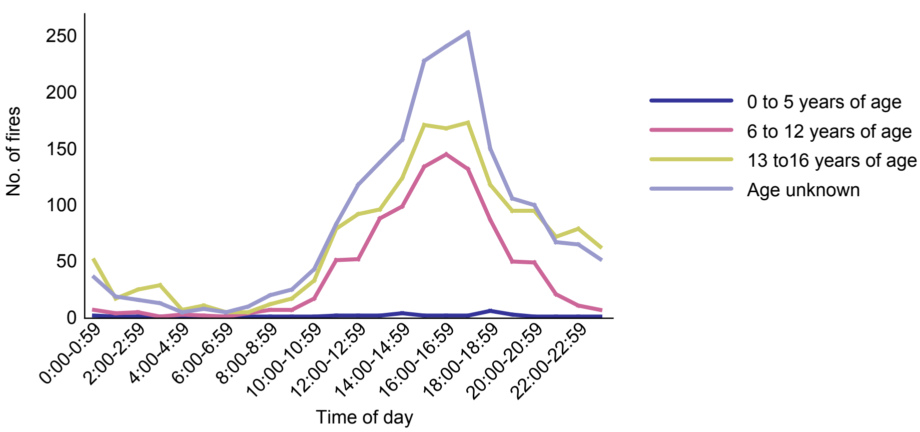
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 95: Non-deliberate child fires, by time of day and day of the week (number)



Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 96: Non-deliberate child fires, by time of day for different age groups (number)



Source: NSWFB 1997–98 to 2001–02 [computer file]

Type of incident

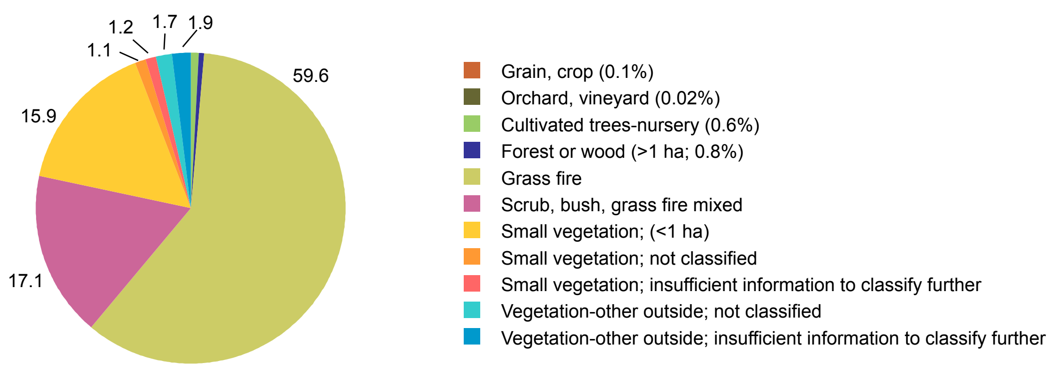
Approximately 60 percent of all vegetation fires the NSWFB attended were grassfires. A further 17 percent were scrub, bush and grass fire mixtures, and 18 percent were classified as small vegetation fires (Figure 97).

The proportion of deliberate fires was remarkably uniform across incident types, although it is noted that comparatively fewer grain and crop fires and subtly greater proportions of orchard, vineyard and nursery fires were classified deliberate. Overall, deliberate causes accounted for 49 to 64 percent of known causes for individual incident type categories (Figure 98).

Grass, scrub, bush grass mixtures and small vegetation fires were the dominant categories of incident types attended across all regions in NSW, although the relative proportion of these categories varied in detail (Figure 99). The highest proportion of small vegetation fires was recorded for the North Coast (29%), and the Riverina and Sydney regions (21%). In contrast comparatively fewer fires (8 to 9%) in the Blue Mountains, Illawarra and New England–North West regions were classified as small vegetation fires. Grassfires accounted for 71 to 81 percent of all fires in both the Illawarra and New England–North West regions, but also in the Murray and Outback regions. The highest proportions (25 to 30%) of scrub bush, grass mixed fires occurred in the Central Coast, Hunter and Blue Mountains regions. Forest fires accounted for the greatest proportion of fires in the Blue Mountains (5%) and to a lesser extent the Hunter, South Coast, and Snowy Mountains regions. In all other regions forest fires comprised one percent or less or all vegetation fire incidents attended.

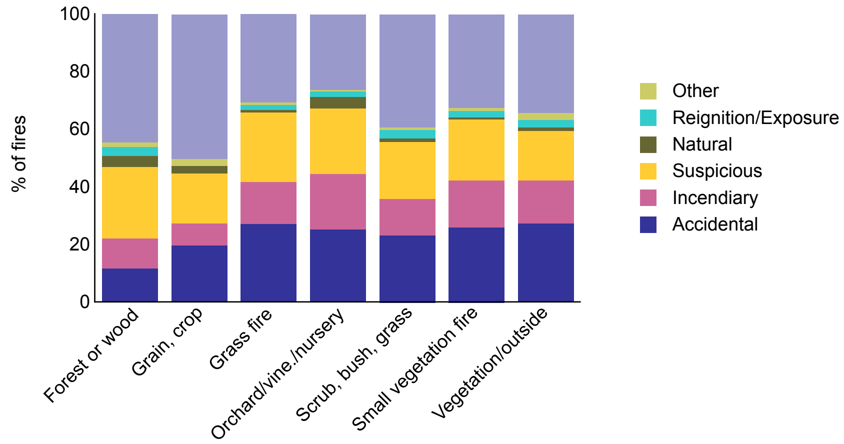
Although it is not possible to determine how many of the fires were, or had the potential (under adverse conditions) to develop into a bushfire, it is recognised that the number of forest fires grassfires, mixed scrub, bush and grass fires was strongly correlated with the total number of vegetation fires attended in each region ($r=1.00$; $p<.001$). Even if grassfires were excluded, the number of mixed grass, scrub and bush fires and forest fires combined were significantly correlated ($r=.87$; $p<.001$) with the total number of vegetation fires attended in each region. The inference is that, overall, the types of incidents that may reasonably have constituted a bushfire, or had the opportunity to develop into a bushfire given sufficient vegetated areas and adverse conditions, varied surprisingly little between urban centres in different regions, and following, those regions that experience the greatest number of vegetation fires overall can be expected to experience the greatest number of bushfires.

Figure 97: Type of incident (percent)



Source: NSWFB 1997–98 to 2001–02 [computer file]

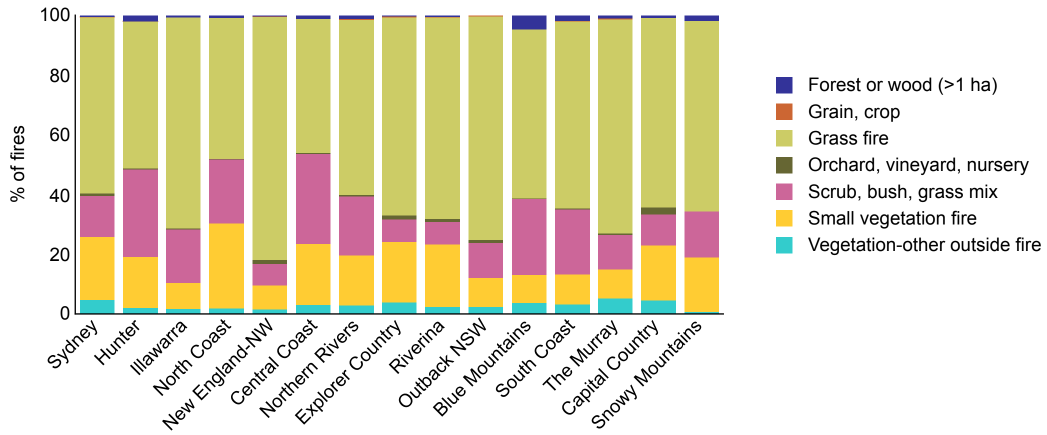
Figure 98: Incident type[a], by cause (percent)



a: The incident type has been summarised to yield seven major categories

Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 99: Incident type[a], by region (percent)



a: The incident type has been summarised to yield seven major categories; and regions are arranged in order of decreased fire frequencies

Source: NSWFB 1997–98 to 2001–02 [computer file]

New South Wales National Parks and Wildlife Service

Background information about the NSW NPWS dataset and its analysis

Important information about the NSW NPWS dataset and the methodology employed to analyse it is outlined below:

- The fire data were sourced from NSW NPWS.
- The database spans from 1995–96 to 2003–04.
- The database does not use AIRS classification codes.
- Cause was defined using the cause variable supplied.

- Incendiary fires included all fires classified as arson, burning off illegally and motor vehicle arson within the cause variable.
- Suspicious fires include all fires where cause = 'arson suspected'.
- Incendiary and suspicious fires are collectively referred to as deliberate fires.
- All natural vegetation fires were the result of lightning.
- Smoking-related fires refer to all fires where cause = 'smoking'. All such fires fall within the 'other' causal category. This differs from most other agencies where they were principally classified as accidental.
- Reserves have been allocated to one of seven regions defined by the NSW NPWS 2007 (see methodology chapter and discussion below). These regions differ from the tourism regions used in the NSWFB and NSWRFS analyses.
- The dataset included information about the area burned.
- Information was available about the tenure, where fires originated and were controlled relative to park boundaries, but no information was available about the fire danger index and weather conditions at the time the fire occurred in approximately one-quarter of cases.

For more detail about these methodologies see the methodology chapter.

Overview

Fires the NSW NPWS attended can be summarised as follows:

- The NSW NPWS records indicate attended at 3,275 fires on or near reserves under their jurisdiction for the seasons encompassing 1995–96 to 2003–04. This represents an average of just over 400 fires per year. The greatest total number of fires occurred in 1997–98 (n=571), although high numbers of fires also occurred in 2000–01, 2001–02, and 2002–03 (Figure 100).
- Fires the NSW NPWS attended both on and near tenures that lie under that organisation's jurisdiction ranged from small vegetation fires to large bushfires. Given the nature of the NSW NPWS's responsibilities is not unreasonable to assume that most fires this agency attended either constituted a bushfire, or had the potential to develop into a bushfire under adverse weather conditions.
- Forty-one percent of all fires were identified as deliberate or deliberate causes were suspected. Such fires comprised almost half of all known causes of fires the NSW NPWS attended.
- Forty-three percent of all fires the NSW NPWS attended occurred in the Sydney and surrounding region, with high numbers of fires also being evident in the Hunter and Mid North Coast and South Coast and Southern Highlands regions.
- Fires the NSW NPWS attended from 1995–96 to 2003–04 burned approximately 3.5 million hectares. Deliberate fires accounted for 21 percent of the total area burned. This principally occurred in 2000–01 and 2001–02. Natural cause was an important factor in large fires spreading from parks onto neighbouring properties, whereas accidental and deliberate causes (commonly legal and illegal burn offs) were one of the key factors in large fires spreading into NSW NPWS tenures.

Cause

Twenty-one percent of all fires were characterised as incendiary, with incendiary activities being suspected in a further 20 percent of cases (Figure 101). Collectively, deliberate causes (incendiary and suspicious combined) accounted for 41 percent of all NSW NPWS fires, 48 percent of instances where the cause of the fire was assigned. One-quarter of all fires resulted from natural causes, with a further 12 percent being accidental in nature.

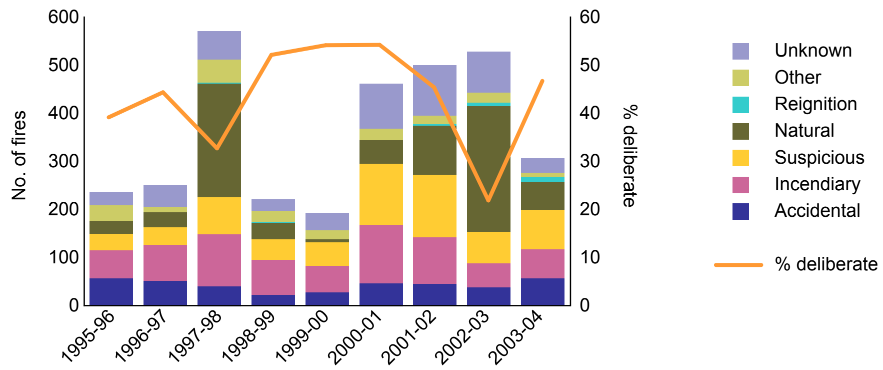
The number and principal causes of fires varied substantially between years. The greatest number of natural fires occurred in 1997–98 and 2002–03 (Figure 100), both seasons associated with El Niño-like weather patterns. Natural fires accounted for 41 and 50 percent in these two seasons, respectively. This compares to rates of three to 21 percent in all other seasons, including 2001–02.

The greatest number of deliberate fires occurred in 2000–01 (n=249) and 2001–02 (n=226; Figure 100). A high number of deliberate fires also occurred in 1997–98 (n=185) and 2003–04 (n=143). Despite the adverse conditions, and the high number of deliberate fires during the previous seasons, the number of deliberate fires in 2002–03 was equivalent to that recorded during less adverse fire seasons like 1998–99 and 1999–2000. The lowest proportion of deliberate fires occurred in the 1997–98 (32%) and 2002–03 (22%) seasons; a reflection of the greater number and hence proportion of natural fires in those season. In years not associated with an El Niño-like weather pattern, deliberate fires constituted 39 to 54 percent of all NSW NPWS-attended fires (Figure 100).

Specific ignition factors

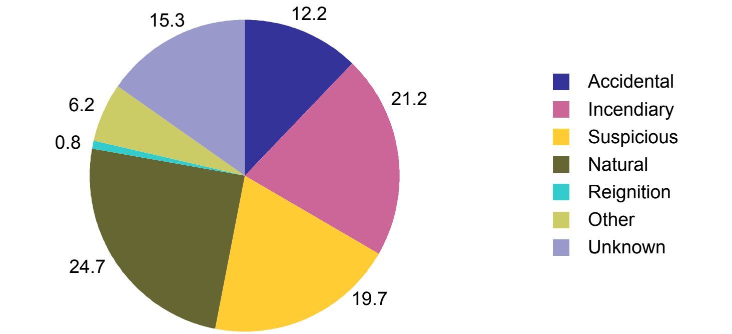
In detail, fires originated from a variety of causes (Figure 102). Deliberate fires incorporated all fires originally classified as arson, suspicious, illegal burn offs, and motor vehicle arson. Arson or suspected arson (excluding motor vehicles) accounted for 36 percent of all NSW NPWS fires from 1995–96 to 2003–04 being the single most dominant factor. Lightning strikes were responsible for all fires classified as natural, and accounted for almost one-quarter of fires. Burning off was involved in 11.9 percent of all fires. Of these almost one-third were illegal. Motor vehicles were implicated in a further 5.3 percent of all fires. Of these one-third (1.5% overall) involved arson or arson was suspected. Fires pertaining to domestic, camping and cooking accounted for 3.1 percent of all fires. Additional factors resulting from industry/farming, public facilities (trains, power lines etc.) comprised a comparatively small proportion of fires.

Figure 100: Seasonal variation in the cause of fires and percentage of deliberate fires



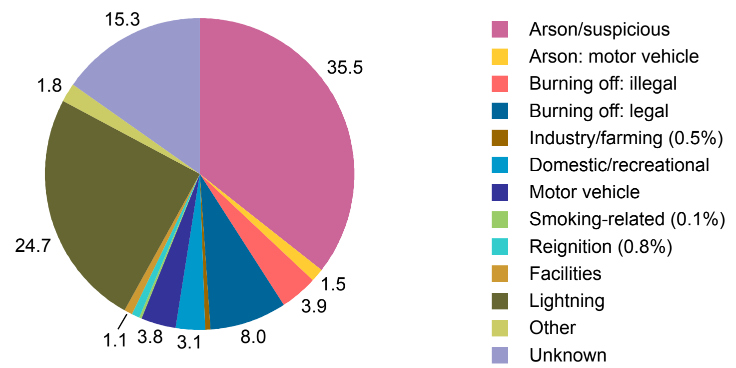
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 101: Cause (percent)



Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 102: Detailed cause (percent)



Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Location

Information about the location of fires is discussed in relation to the region and reserves on which fires occurred, the tenure of lands, and the location of the point of origin and final suppression relative to NSW NPWS tenure boundaries.

Region

Region definition: For reasons outlined in the methodology, the allocation of NSW NPWS fires to particular regions differed to that used for the NSWFB and NSWRFS. The system adopted is based on the classification used for national parks outlined by the NSW NPWS (2007b). The seven regions defined therein include Sydney and surrounds, Hunter and Mid North Coast, Northern Rivers, South Coast and Southern Highlands, New England Tablelands, Central NSW, and Outback NSW. In this classification, fires were allocated to a specific region on the basis of the reserve name. The distribution of these regions is illustrated in Figure 103, and a brief description of the regions, including their makeup relative to the regional classification provided with the NSW NPWS data, are outlined below:

- **Sydney and surrounds** is centred on Sydney but incorporated parks extending from the Nattai and Thirlmere Lakes national parks in the south (just north of Wollongong) to the Lake Macquarie State Conservation Area and Wallarah National Park in the north (just south of Newcastle), and to the Gardens of Stone and Kanangra–Boyd national parks in the west (Lithgow region). Thirty percent of fires in the Sydney and surrounding region occurred in areas formerly classified within the NSW NPWS regions of the Central Coast–Hunter (Figure 104). A further 26 percent were from the NPWS Blue Mountains region, 26 percent from the NPWS Sydney South region and 14 percent from the NPWS Sydney North region. Just four percent were from the central Sydney metropolitan region.
- The **Hunter–Mid North Coast** region defines an elbow shape (Figure 103) that extends from just south of Newcastle (Watagans National Park) to just north of Coffs Harbour (Coffs Coast Regional Park), and inland as far as the Towarri National Park (northwest of Scone) in the south and the Nymboi–Binderay National Park in the north. Fifty-three percent of fires in this region were from the NPWS Central Coast–Hunter region, 34 percent in the NPWS Mid North Coast region, and 13 percent from the NPWS North Coast region (Figure 104).
- The **Northern Rivers** region encompasses all reserves on the coast between the Hunter–Mid North Coast region and the Queensland border, and as far inland as the Tooloom and Koreelah national parks in the north. Fifty-one percent of fires in this region were originally classified with the NPWS Northern Rivers region; the other 48 percent were from the NPWS North Coast region (recorded as NOC & NCR codes within the database provided).
- The **New England Tablelands** region incorporates reserves from as far south as Mummel Gulf National Park, to the border in the north, and from Kwiambal and Warrabadah in the west to just east of Dorrigo. Seventy percent of fires in this area were originally from the NPWS Northern Tablelands region, 26 percent from the NPWS North Coast region, and four percent from the NPWS Mid North Coast region (Figure 104).
- The **South Coast and Southern Highlands** region encompassed reserves along the South Coast from Wollongong (Illawarra Escarpment State Conservation Area) to the Victorian border, and as far inland as the Brindabella, Kosciouszko and Woomargama reserves. Thirty-nine percent of fires were from the NPWS Snowy Mountains and NPWS Southwest Slopes regions, 33 percent from the NPWS South Coast, and 28 percent from the NPWS Far South Coast region (Figure 104).
- The **Central West** defines a roughly north–northeast trending region inland of the aforementioned regions, encompassing parks near Narrabri, Coonabarabran, Dubbo, Mudgee, Bathurst, Forbes, and Wagga Wagga. This region extends as far inland as the Cocoparra and Oolambeyan national parks. Thirty-nine percent of fires in this region were from the original NPWS Northern Plains region, 34 percent from the NPWS Central West region, and the remainder from the NPWS Blue Mountains, North Coast, Northern Tablelands and Riverina regions.
- **Outback NSW** incorporates all regions further west, with a further seven percent coming from the NPWS Far West and 28 percent from the NPWS Riverina regions (Figure 104).

- **Total number of fires**: Forty-three percent of all fires the NSW NPWS attended occurred in the Sydney and surrounding region. A further 19 and 17 percent of fires were located in the neighbouring regions of the Hunter–Mid North Coast and the South Coast and Southern Highlands, respectively (Figure 105). Nine percent occurred on the New England Tablelands and eight percent in the Northern Rivers region. Just 4.4 percent of fires were located further inland, in the Central West and Outback NSW regions.

Temporal changes occurred in the regional distribution of fires from 1995–96 to 2003–04. Despite the large spike in fire numbers in the Sydney and surrounding region in 1997–98 (Figure 106), this region consistently accounted for 50 to 56 percent of NSW NPWS-attended fires from 1996–97 to 1999–2000 (Figure 107). The proportion of fires in this region subsequently decreased to below 40 percent from 2000–01 onwards. This was despite increased numbers of fires for both 2000–01 and 2002–03. Increasingly other regions, particularly the Hunter–Mid North Coast, New England Tablelands, and to a lesser extent the Richmond River regions, contributed to higher proportions of NSW NPWS-attended fires during the latter half of the observation period.

From 1995–96 to 1998–99, the NSW NPWS attended an average 42 fires per year in the Hunter–Mid North Coast region, with that region accounting for 12 to 15 percent (Figure 107). However, from 2000–01 to 2002–03 the total number increased to an average of 113 per year, peaking at 140 in the 2001–02 season. Simultaneously, the percentage of NSW NPWS fires in the Hunter–Mid North Coast region increased from approximately 15 percent in 1995–96 to 1998–99 to 22 to 28 percent of fires from 1999–2000 to 2002–03. Both the number and percentage of all fires that occurred in the Hunter–Mid North Coast region, returned to the pre-2000–01 levels during the 2003–04 season.

The number of fires occurring on or near reserves in the New England Tablelands increased from an average of 18 for 1995–96 to 1999–2000 to an average of 51 per year for the 2000–01 to 2003–04 interval. In contrast, the number of fires occurring in the South Coast and South Highlands region was markedly higher during both the 1997–98 and 2002–03 El Niño events than during other seasons (Figure 107), highlighting the potential role that large scale climatic conditions play in the increased incidence of fires in that region. This was particularly noticeable for both the Far South Coast and Snowy Mountains areas, although in 2002–03 higher numbers also occurred on the South West Slopes. Surprisingly the South Coast and Highlands also accounted for a high proportion of all fires in 2003–04.

Cause: The cause of fires on or near NSW NPWS reserves varied markedly between regions. The greatest number of deliberate fires (including arson, suspicious, arson-motor vehicle and illegal burn offs) occurred in the Sydney and surrounding region, followed by the Hunter–Mid North Coast, South Coast and Southern Highlands, and the Northern Rivers regions (Figure 108). Deliberate causes accounted for the highest percentage of fires in the Northern Rivers region (59%), Hunter–Mid North Coast (48%) and Sydney and surrounds (44%; Figure 108).

The relative importance of types of illegal fire activity also varied between regions. Arson involving motor vehicles was a phenomenon principally experienced in the Sydney and surrounding region, although several instances were reported in the Hunter–Mid North Coast and the South Coast and Southern Highlands regions.

The highest number of fires resulting from burning off (illegal and legal combined) occurred in the New England Tablelands, Hunter–Mid North Coast and Northern Rivers regions (Figure 109). Burning off accounted for 37 and 27 percent of all fires in the New England Tablelands and Northern Rivers regions, respectively. Not surprisingly, regions that recorded high instances of burning off also recorded the highest proportion of illegal burns. Fifty-two percent of all burns in the Northern Rivers region and 36 percent of burns in the New England Tablelands regions were illegal. The proportion of burns that were illegal in other areas was typically 20 to 27 percent.

Fires started by lightning strikes were most frequent in the Sydney and surrounding region and the South Coast and Southern Highlands regions (Figure 110), highlighting the fundamental vulnerability of these areas to natural fires. In the absence of significant other causes, lightning was responsible for 67 and 58 percent of all fires in the Outback and Central West, respectively. This compares with values of 25 and 37 percent in the Sydney and surrounds and the South Coast and Southern Highlands, respectively.

Sydney and surrounds region: Marked differences occurred in the cause and number of fires in the Sydney and surrounds region at a sub-region scale. High numbers of natural fires occurred in the Blue Mountains and Central Coast–Hunter, areas that lie on the perimeter of the metropolitan centre, contributing to a high incidence of fires in these areas overall (Figure 111). Deliberate firesetting was an important issue across the entire region, but owing to the preponderance of natural fires, accounted for a lower percentage of all fires in the Blue Mountains and Central Coast–Hunter sub-regions. Between 55 and 65 percent of fires in the Sydney, Sydney North and Sydney South sub-regions were deliberately lit. Within the metropolitan area, the greatest number of deliberate fires occurred in southern Sydney, a finding that is consistent with both the NSWFB and NSWRFS data.

The Sydney and surrounds region experienced the greatest number of fires in 1997–98, followed by 2001–02, and 2000–01 (Figure 112), a reflection of higher frequencies of both natural and deliberate fires during these years. While 2001–02 is sometimes singled out as being a particularly adverse year for deliberate fires, the number of deliberately lit fires in that year was actually lower than in the previous year. Despite the adverse conditions, fewer deliberate fires were recorded in the Sydney region in 2002–03 than in any other year analysed.

Hunter–Mid North Coast region: The Hunter–Mid North Coast also experienced the greatest numbers of fires in 1997–98 and from 2000–01 to 2002–03; unlike the Sydney and surrounds region, the Hunter–Mid North Coast region's greatest number of fires occurred during the latter half of the observation period (Figure 113). This was an area strongly affected by the December–January 2001–02 fires.

Deliberate fires accounted for almost half of all fires in the region. The greatest number of fires occurred in 1997–98, 2000–01 and 2001–02 (Figure 113), coincident with the increases evident for the Sydney and surrounds region. Like that region, a marked decrease in deliberate fire numbers occurred in 2002–03 despite the adversity of the season. With the exception of 1998–99, where 90 percent of fires were deliberate, and 2002–03, where low proportions of deliberate fires were an artefact of high natural fire numbers, the percentage of fires that result from deliberate causes in the Hunter and Mid North Coast region remained comparatively stable throughout the observation period, at approximately 50 percent.

South Coast and Southern Highlands region: The principal cause of fires in the South Coast region varied markedly across the region, a finding that is not surprising in light of the regional differences in climate, vegetation, land-use, population density and demographics. The Snowy Mountain–South West Slopes sub-region recorded the greatest number of fires of any sub-region (Figure 114). A high proportion of these were the result of natural causes. In contrast, the large numbers of fires in the South Coast sub-region largely reflect a high incidence of deliberate firesetting. Roughly half of all fires on the South Coast were deliberate, rates that are equivalent to that observed for the Hunter and Mid North Coast region. The Far South Coast region appears intermediate between the two areas, experiencing a higher incidence of natural fires that than the South Coast, but also a higher number of deliberately lit fires than the Snowy Mountains–South West Slopes. Of the 159 fires that occurred on the Far South Coast, 38 percent resulted from natural causes, with a further 31 percent being the result of deliberate lightings.

High numbers of natural fires during both 1997–98 and 2002–03 El Niño events contributed to higher than average numbers of fires in these two years. Increases principally occurred for the Far South Coast and the Snowy Mountains–South West slopes sub-regions. The higher than expected number of fires in 2003–04 principally reflected a doubling in the number of deliberate fires in that year (Figure 115).

Northern Rivers region: Comparatively few fires occurred in the Northern Rivers region from 1995–96 to 1999–2000. This was followed by a massive increase the number of fires in 2000–01 (Figure 116). Although fire frequencies remained elevated during the later half of the observation period, the number of fires systematically decreased from 2000–01 onwards, almost reaching pre-2000–01 levels by 2003–04. These temporal variations were evident in both the Northern Rivers and North Coast sub-regions. Higher numbers of fires from 2000–01 to 2002–03 principally reflected greater numbers of deliberate fires. The actual numbers of deliberate fires were comparable across the North Coast and Northern Rivers sub-regions, but deliberate causes accounted for 67 percent of all fires in the North Coast sub-region as compared with 50 percent for the Northern Rivers sub-region.

Figure 103: Map of NSW NPWS regions

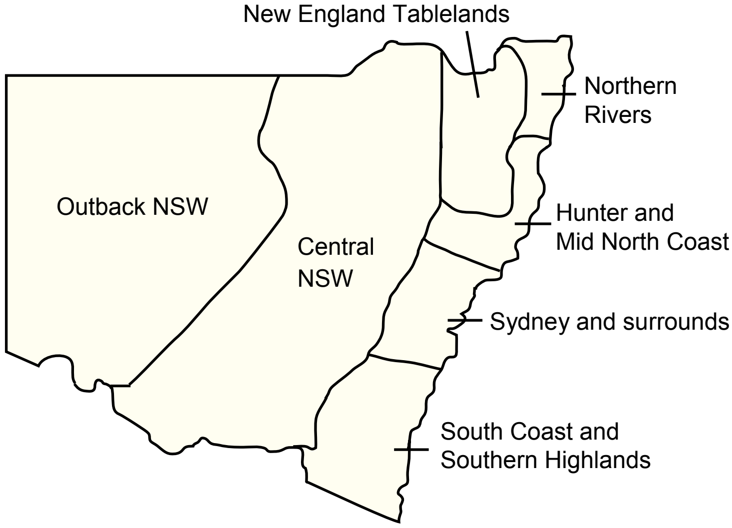
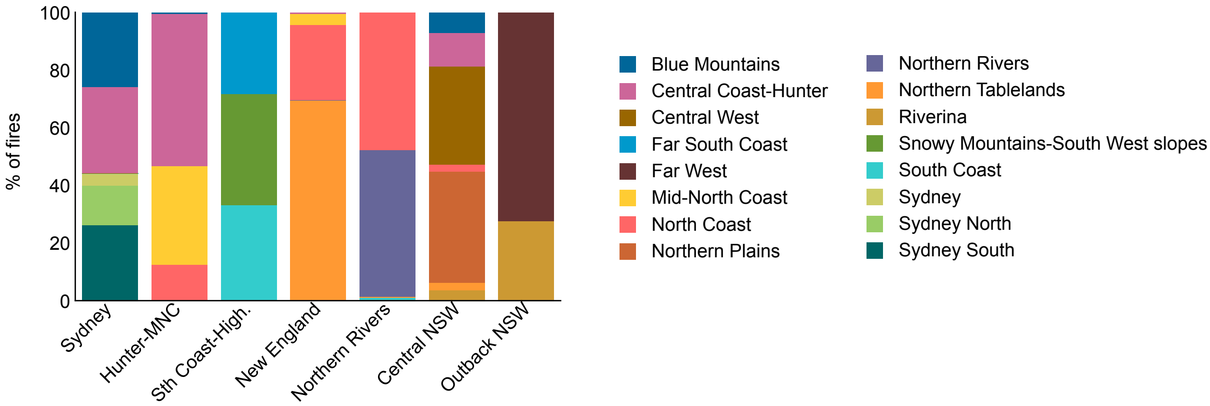


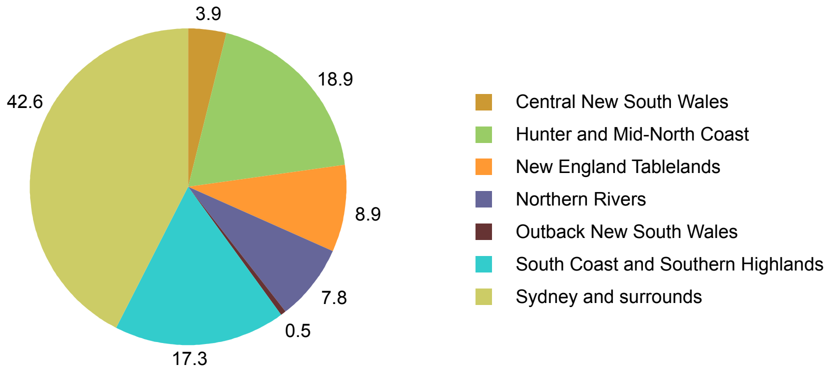
Figure 104: NPWS regions[a], by original sub-region classification (percent)



a: New England = New England Tablelands; Sth Coast-High. = South Coast and Southern Highlands; Hunter-MNC = Hunter and Mid North Coast; Sydney = Sydney and surrounds

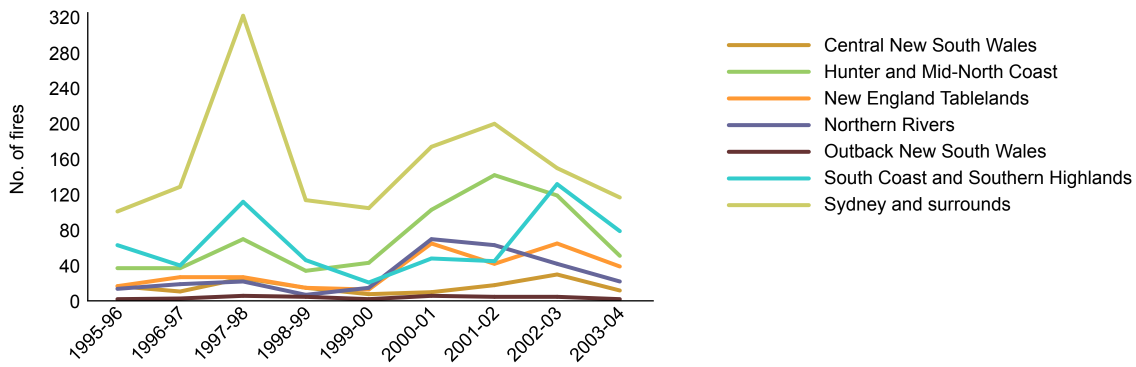
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 105: All fires, by region (percent)



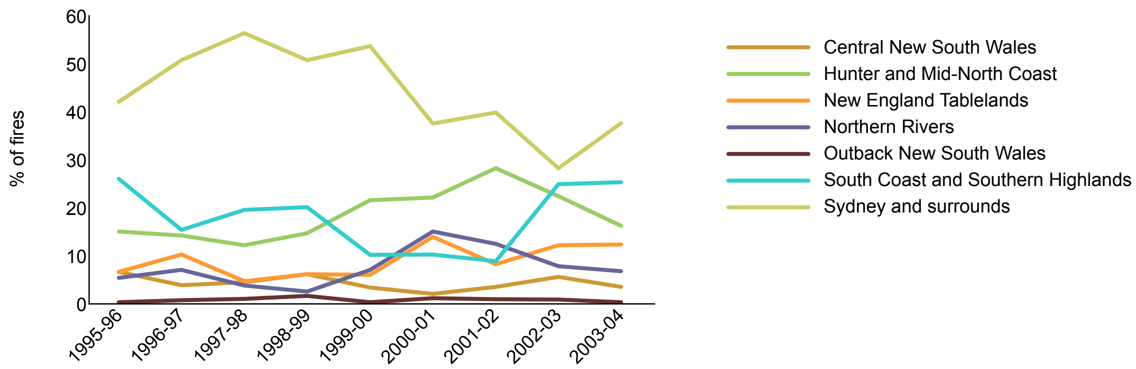
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 106: All fires, by region and season (number)



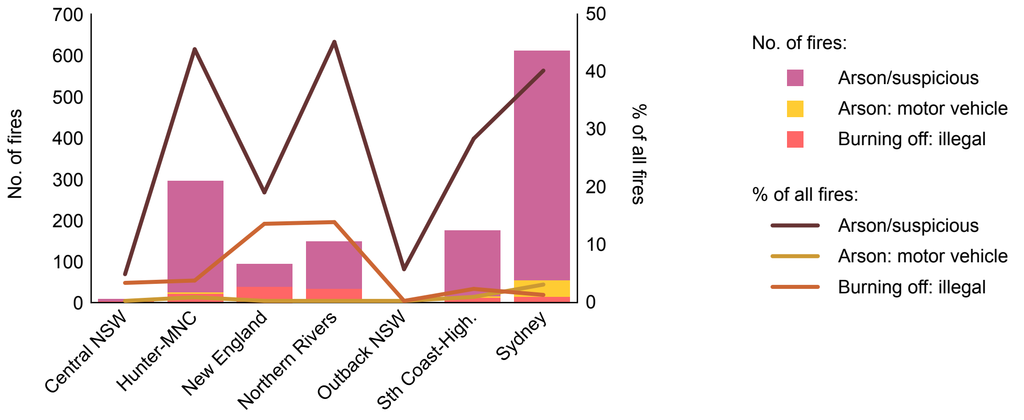
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 107: All fires, by region and season (percent)



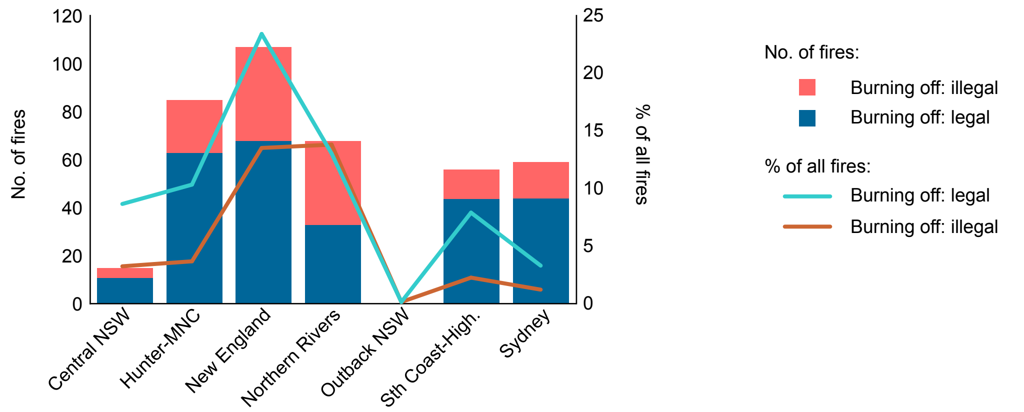
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 108: Deliberate fires, by specific cause and region



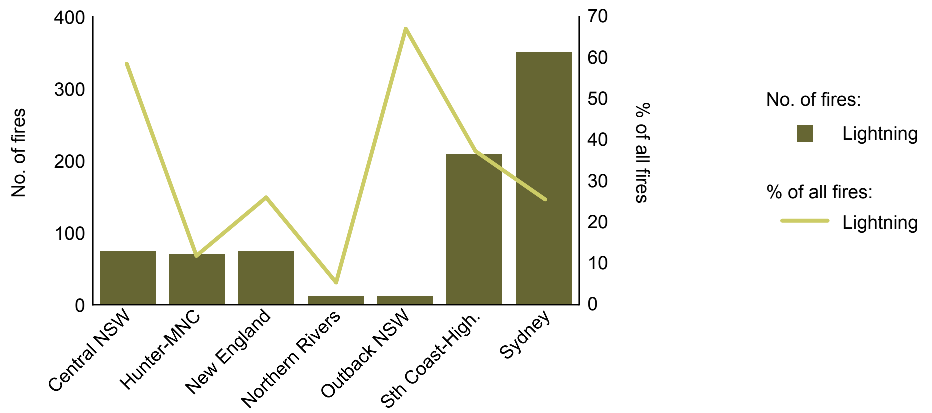
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 109: Burn offs, by region



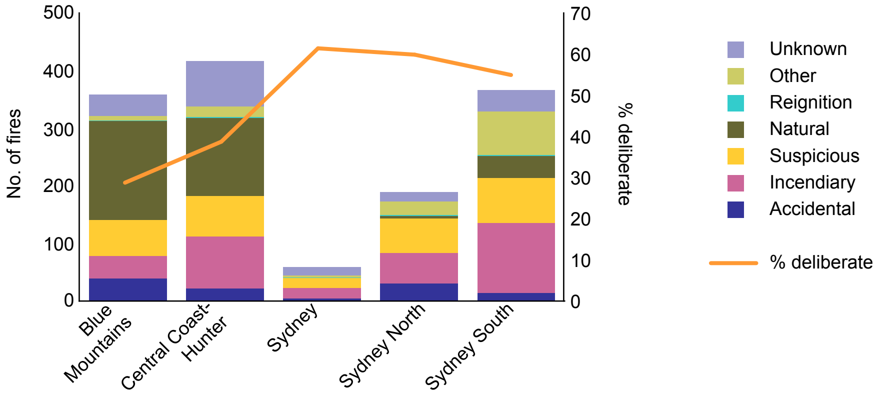
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 110: Natural fires, by region



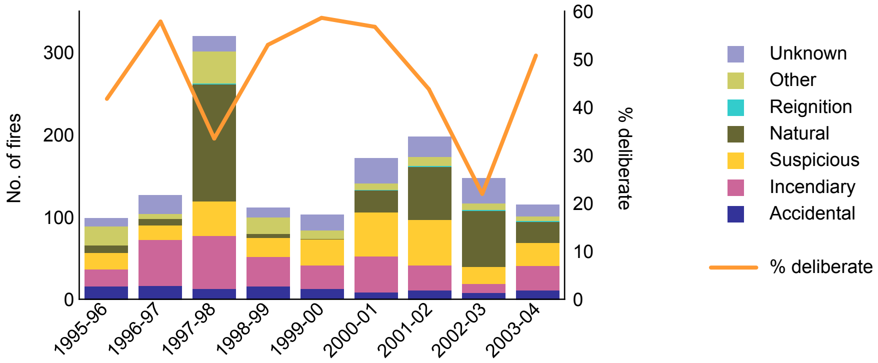
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 111: Sub-regions in the Sydney and surrounds region, by cause



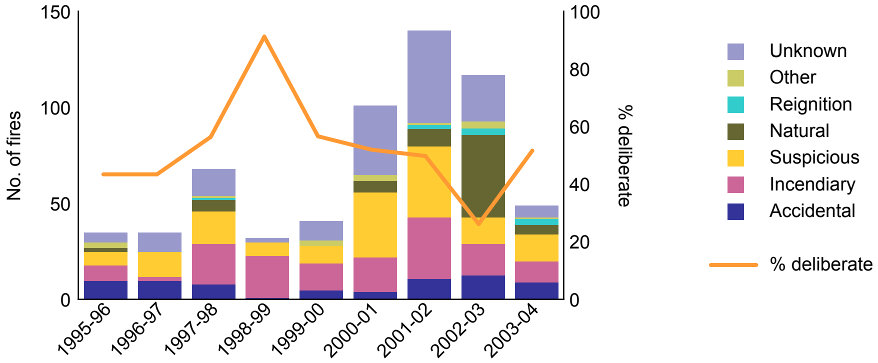
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 112: Fires in the Sydney and surrounds region, by cause for each season



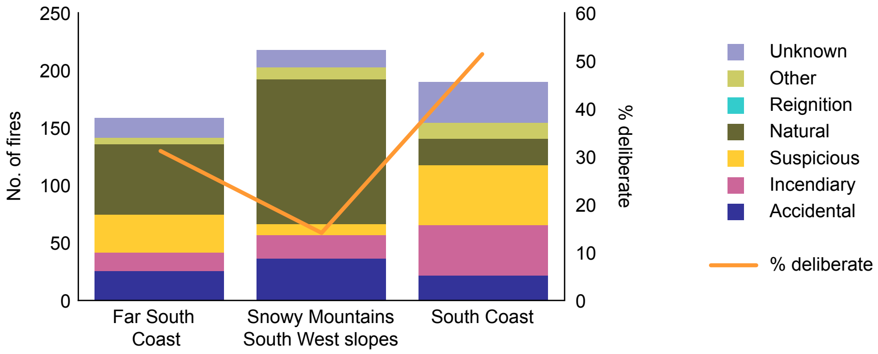
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 113: Cause of fires in the Hunter–Mid North Coast region each season



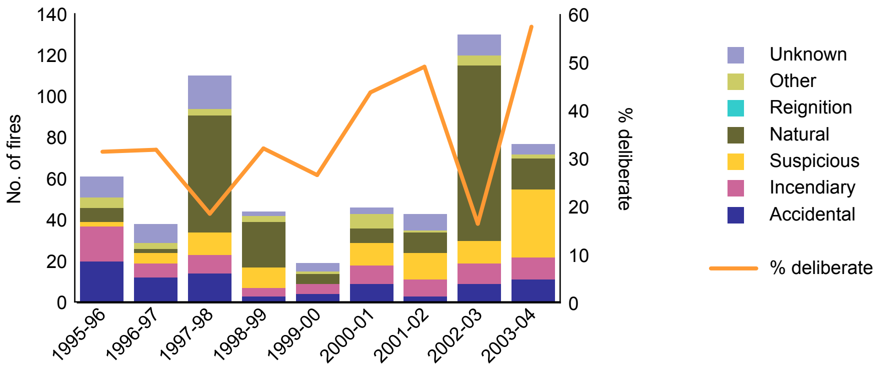
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 114: Sub-regions of the South Coast and Southern Highlands region, by cause



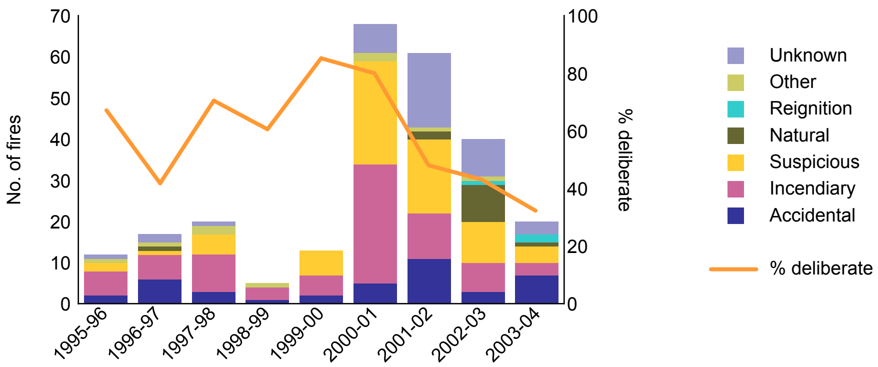
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 115: South Coast and Southern Highlands region fires, by cause each year



Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 116: Fires in the Northern Rivers region, by cause each year



Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Reserve

The number of fires experienced in eight years varied markedly between reserves. More than 200 fires occurred in or near the Wollemi National Park from 1995–96 to 2003–04 (Figure 117). Another three reserves (Blue Mountains, Kosciouszko and Royal national parks) recorded 100 to 200 fires and five recorded 50 to 99 fires (Ku-ring-gai Chase, Yengo, Morton, Yuraygir and Deua national parks). Of these parks, five occurred in the Sydney and surrounds region, three in the South Coast and Southern Highlands and one in the Northern Rivers regions. Twenty-five to 49 fires were documented for a further 14 reserves over the eight-year interval.

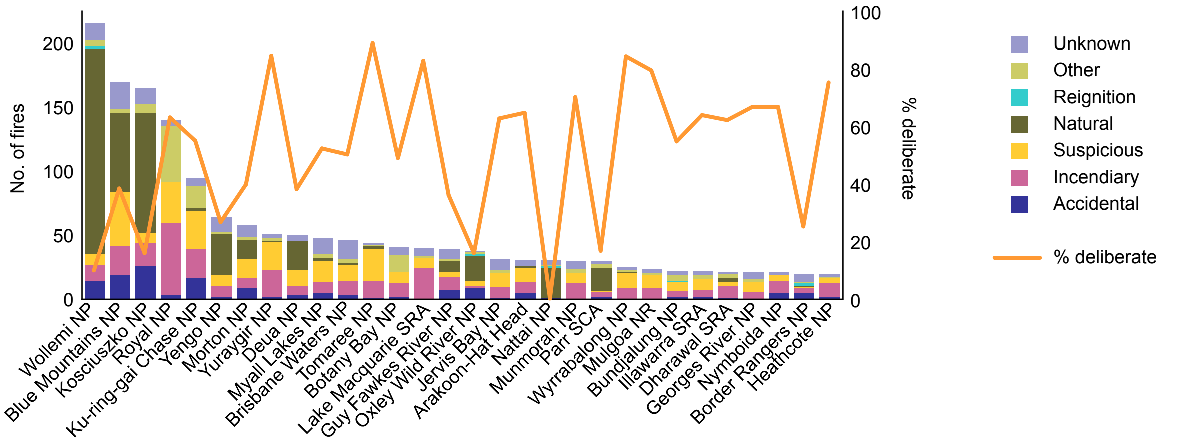
The causes of high fire numbers also varied markedly between reserves (Figure 117). Natural fires were the principal cause of the greater numbers of fires in the Wollemi and Kosciouszko national parks, whereas in the Blue Mountains National Park both natural and deliberate fires featured.

Fires in the Royal National Park predominantly arose from deliberate causes (63% deliberate), with 88 deliberate fires occurring in or near the park in eight years. Other parks to experience in excess of 50 deliberate fires in eight years included the Blue Mountains and Ku-ring-gai Chase national parks. The Yuraygir National Park (Northern Rivers) was the only reserve to record 40 to 49 deliberate fires. Thirty to 39 deliberate fires occurred in the Tomaree National Park and Lake Macquarie State Recreation Area. In these three reserves, deliberate causes accounted for 80 to 90 percent of all fires in those parks.

The proportion of fires resulting from deliberate causes was highly variable across reserves, even for parks with a large number of fires. However, it was common that 50 to 70 percent fires were deliberately lit in reserves documenting 20 or more fires in total.

Of the 48 cases involving motor vehicle arson 17 (35%) occurred in the Royal National Park, with this causes accounting for 39 percent of all deliberate fires in that reserve. A further 10 cases (21%) involving a motor vehicle occurred in the Dharawal State Recreation Area, and this cause was responsible for 77 percent of fires in or near that reserve. This highlights that motor vehicle arson may be a serial offence committed by 'locals' within geographically small areas.

Figure 117: Reserve, by cause



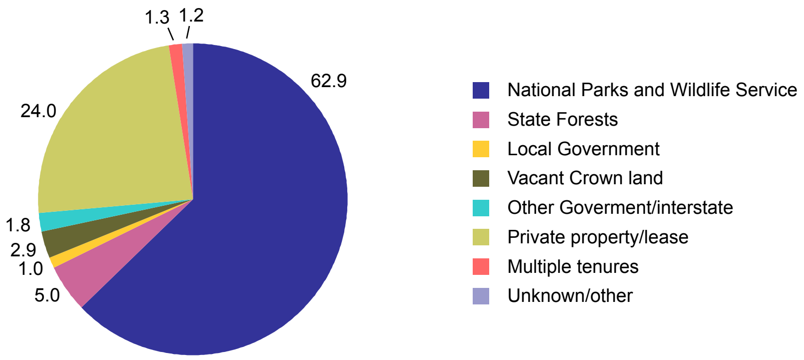
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Tenure

Almost two-thirds of all fires the NSW NPWS attended occurred on lands within their tenure (Figure 118). A further 24 percent were on private property or leasehold land, five percent were in state forests and three percent were on vacant crown land.

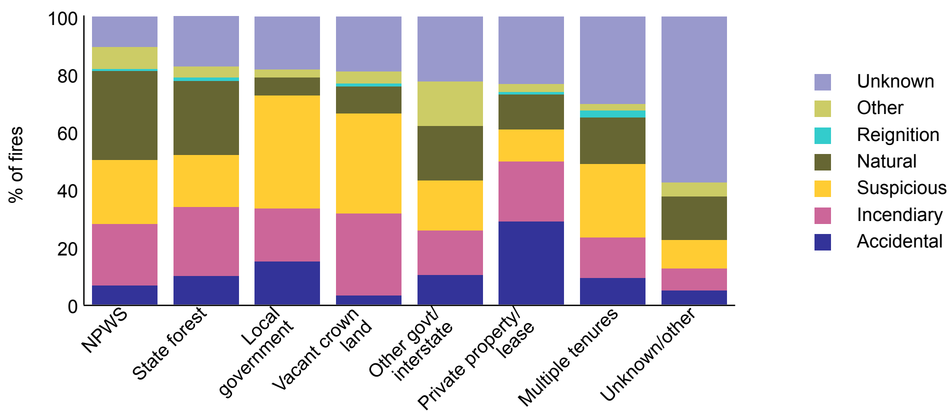
Proportionally more natural fires occurred in NPWS and State Forest tenures than in any other category, whereas deliberate causes accounted for the highest proportions of fires on local government lands and vacant Crown land (approximately 60%). Forty-one to 43 percent of all fires on NPWS and State Forest tenures were deliberately lit (Figure 119).

Figure 118: Tenure (percent)



Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 119: Tenure, by cause



Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Point of origin–suppression (on–off status)

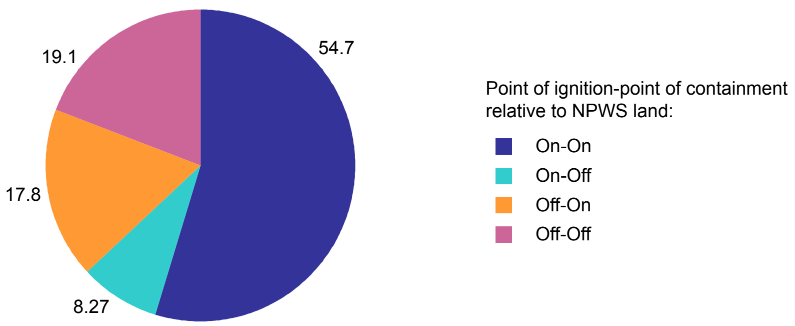
Sixty-three percent of all fires the NSW NPWS attended originated on NPWS reserves (Figure 120). The majority of these were contained on those reserves. In contrast, there was a roughly equal likelihood that fires started off-park were contained off-park as opposed to spreading onto neighbouring NPWS reserves. Moreover, of those fires the NSW NPWS attended, a fire that started off-park and crossed onto park lands was twice as likely as a fire starting on parks lands but crossing onto neighbouring properties.

A higher proportion of fires that originated on NPWS reserves resulted from natural causes when compared to off-park fires (Figure 121). This was particularly evident for fires that subsequently transgressed park boundaries. However, a slightly higher proportion of all fires that started on NSW NPWS lands resulted from deliberate causes, when compared to those originating off-park. To some extent this may be counterbalanced by the higher incidence of fires of unknown causes in off-park categories.

The likelihood of deliberate fires occurring on- or off-park varied depending on the specific cause of the fire. Not surprisingly, most illegal burn offs originated off-park, but between half and two-thirds of all those fires subsequently transgressed park boundaries (Figure 122). Fires resulting from motor vehicle arson typically occurred on-park and were subsequently contained on-park. These figures are dominated by cases of motor vehicle arson in the Royal National Park. Approximately two-thirds of all fires identified as arson or suspicious (not involving a motor vehicle) also occurred on-park. Of these, the majority were contained on-park. Of the one-third of deliberate arson fires that originating off-park, roughly one-third subsequently transgressed parks boundaries.

The inherent tendencies for deliberate fires to originate on- or off-park, and the likelihood that they transgressed boundaries was a function of both the specific causal factors, the size of the park, and ease of containing the blaze, and therefore necessarily varies between regions. The highest proportion of deliberate fires that originated on-park was recorded in the Sydney and surrounds region, and the neighbouring South Coast and Southern Highlands and the Hunter–Mid North Coast regions (Figure 123). Fires that started off-park but subsequently transgressed park boundaries were most evident in those regions where there was a high proportion of legal and illegal burn offs, namely the New England Tablelands and Northern Rivers regions. The overwhelming majority of off-park fires originated on private property or leases. Nevertheless, many fires also started in state forests and to a lesser extent on vacant Crown land.

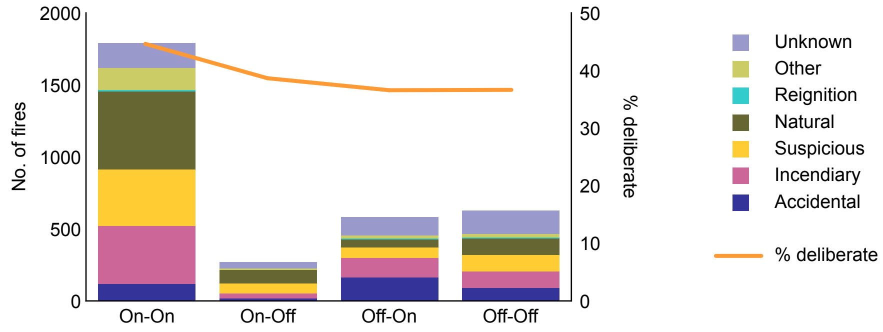
Figure 120: On–off status (percent)[a]



a: on-* and off-*, refers to fires that starting on and off a park reserve respectively; *- on and *- off refers to fires that were contained on- and off-park respectively

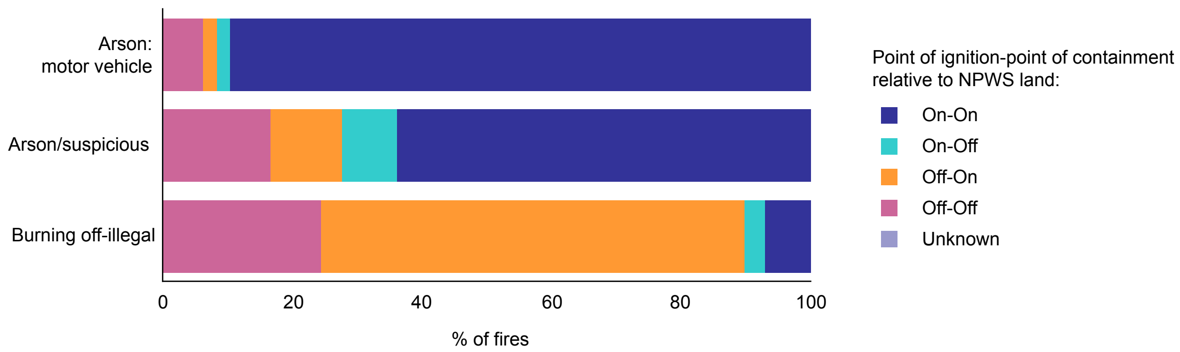
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 121: On–off status, by cause



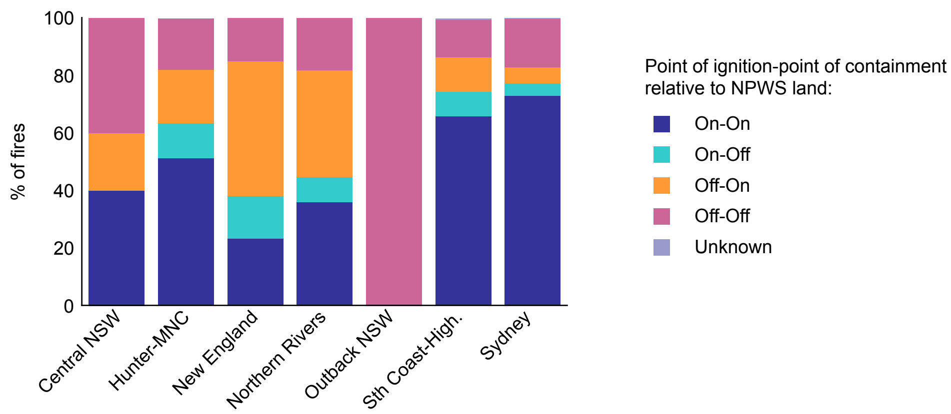
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 122: Specific deliberate fire causes, by on–off (percent)



Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 123: Deliberate fires in each region, by on–off status (percent)



Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Timing

The timing of fires is examined by week of the year and the day of the week on which fires occurred, as well as the time that fire crews were in attendance.

Week of the year

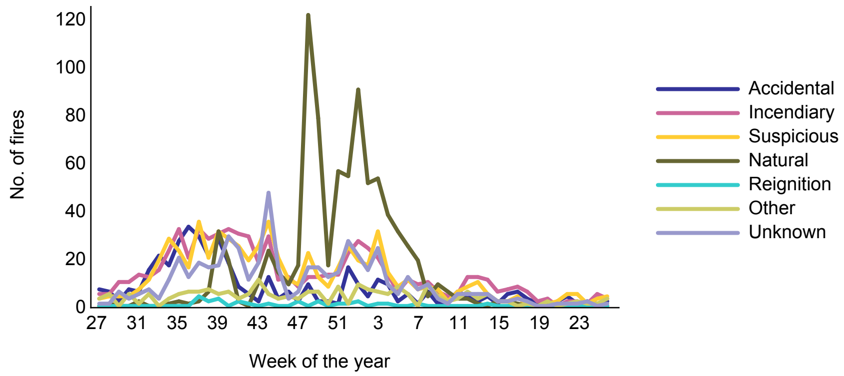
The timing of fires by week of the year was highly cause-specific. Natural fires principally occurred from mid December to the end of February, although earlier occurrences are noted (Figure 124). Accidental fires occurred throughout the year, but the main peak occurred from early August to mid October, reflecting the fact that most legal burn offs in NSW occur within this period (Figure 125). A smaller increase in accidental fires resulting from recreational activities occurred during the Christmas school holidays.

Deliberate fires also occurred throughout the year, but there were two major peaks in activity, mid August to mid November and mid December to early February. This general trend was evident for all fires classified as either arson or suspicious. However, deliberate fires resulting from illegal burn offs principally coincided with the first peak, concomitant with the peak in legal burn offs. Fires resulting from arson involving motor vehicles occurred throughout the year, but with a peak coincident with the last school term (mid September to early November).

Considerable variation was evident in the timing and maximum intensity of fires across fire seasons. Until 2000–01, the number of fires attended in any particularly week was comparatively small (less than 20 to 25; Figure 126). The only notable exception was during 1997–98, an El Niño event, when very high numbers of fires – many natural – occurred during week 48 (early December) and one in the first week of January. The distribution for fires during the 21st century has been somewhat different. In 2000–01, a large spike in activity occurred early September to late October, with a smaller peak in early January (Figure 127). In 2001–02, several smaller peaks occurred in weeks 34 and 41, followed by three large peaks in weeks 44 (early November), 49 (early December) and 52 (late December). In 2002–03, elevated fire numbers occurred from late September to mid January, with increased fire numbers occurring during a number of weeks within that interval. In contrast, the trend in 2003–04 was more similar to that of 2000–01, albeit at reduced numbers. Peaks in that season occurred in September–early October and to a lesser extent in January. These temporal trends defined within the NSW NPWS database are broadly consistent with those described within the NSWFB and NSWRFS data.

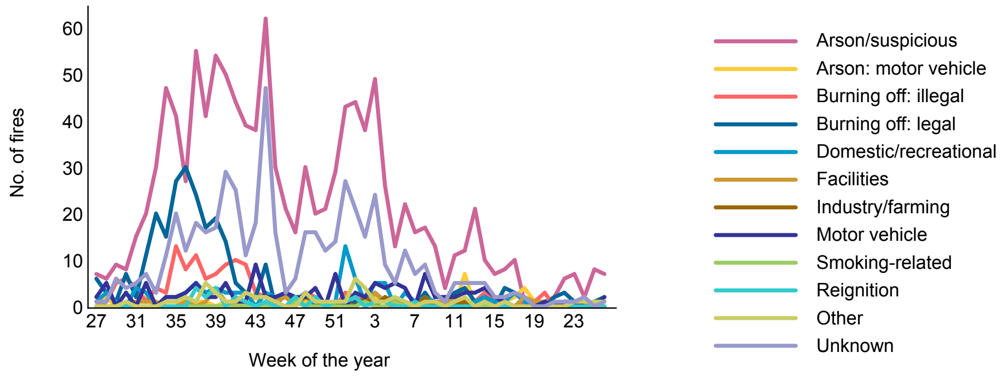
The timing of fires varied markedly between regions, being dependent not only on the inherent climatic conditions, but also the types of practices that lead to fire. Both the Sydney and surrounds region and the Hunter–Mid North Coast region experienced two peaks of activity during September–November and late December–January, coincident with that described above for deliberate fires (Figure 128). In contrast, fires in the New England Tablelands region primarily occurred in September and October, principally because many of those fires resulted from burn offs. Most fires in the Northern Rivers region occurred during August–October, although increased numbers were also evident in January and February. Seasonality in fire occurrences was less well defined for the South Coast and Southern Highlands regions, probably because of the diversity in geographical conditions and the causes of fires within this region.

Figure 124: Week of year, by cause (number)



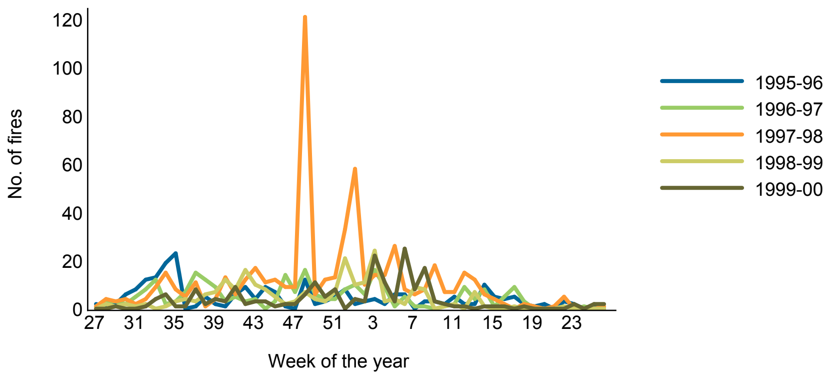
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 125: Specific causes of non-natural fires, by week of the year (number)



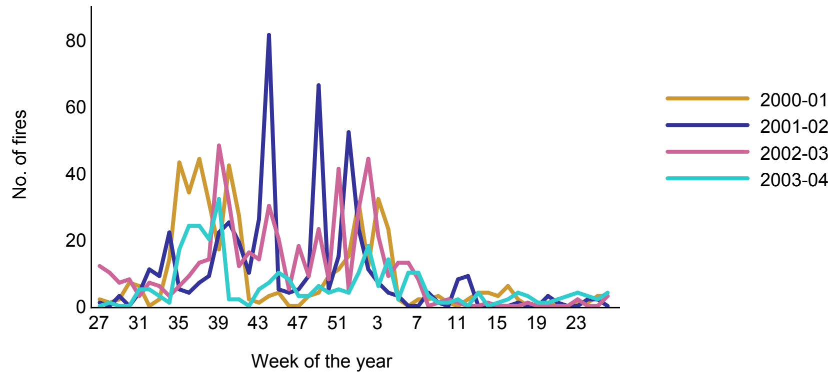
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 126: Week of year, by year, 1995–96 to 1999–2000 (number)



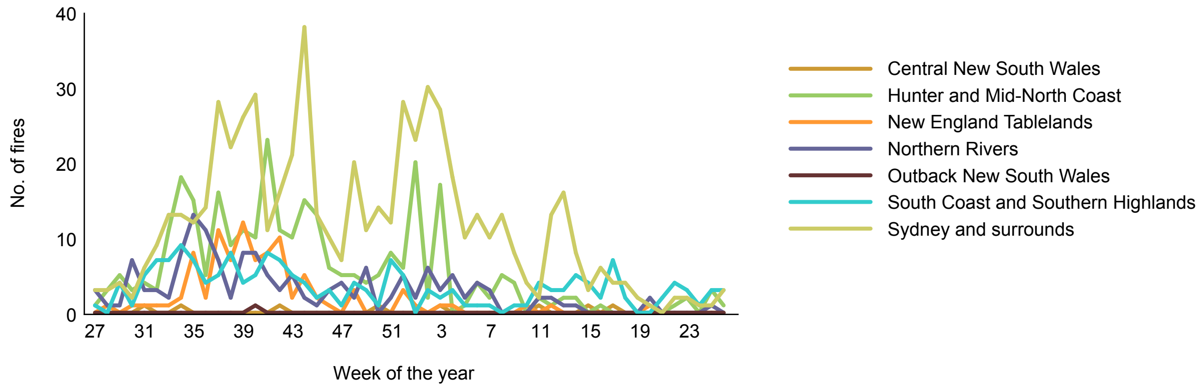
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 127: Week of year, by year, 2000–01 to 2003–04 (number)



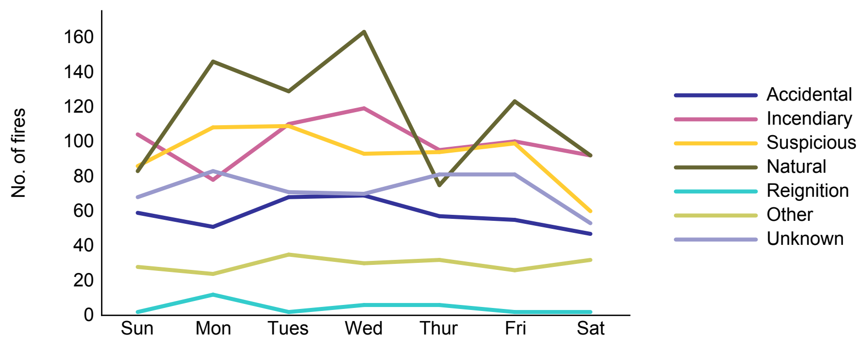
Source: NSW NPWS 2000–01 to 2003–04 [computer file]

Figure 128: Week of the year, by region (number)



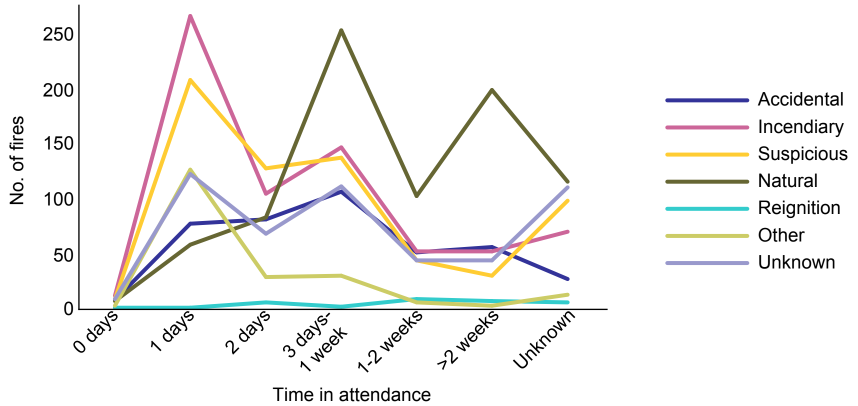
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 129: Day of week, by cause (number)



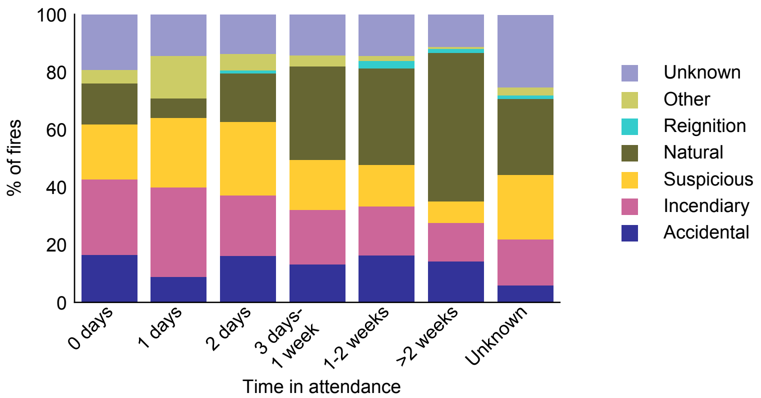
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 130: Number of days attended, by cause (number)



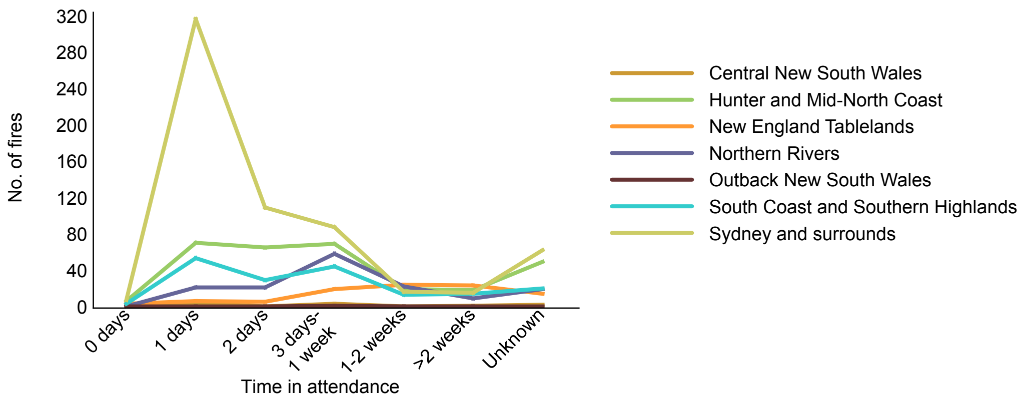
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 131: Number of days attended, by cause (percent)



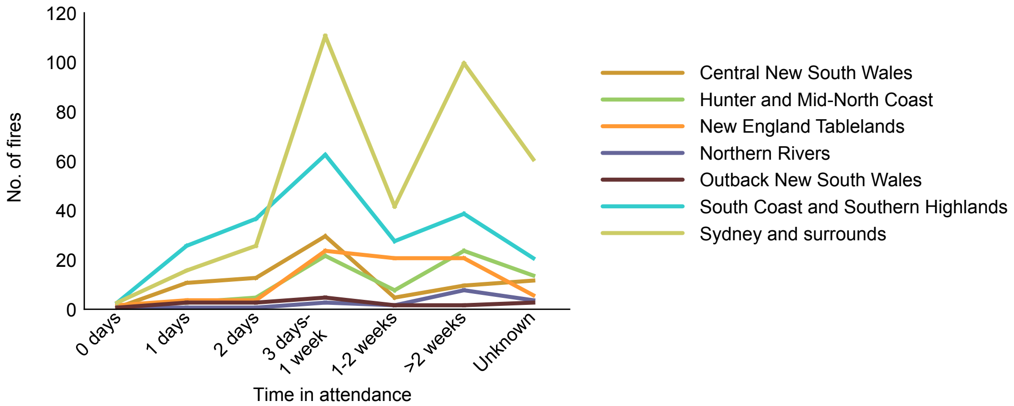
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 132: Number of days attended for deliberate fires, by region (number)



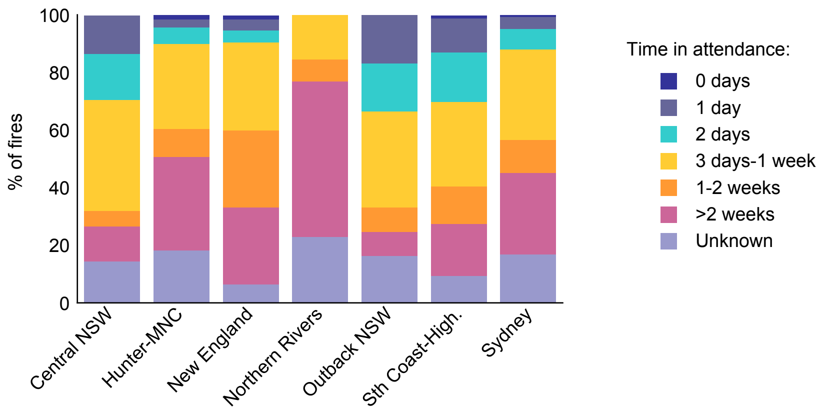
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 133: Number of days attended for natural fires, by region (number)



Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 134: Time in attendance, by region (percent)



Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Day of the week

There is no evidence within the NSW NPWS data that fires of a particular cause where inherently more likely to occur on one day or another (Figure 129). This is unlike the trend observed for most urban and rural fire services. Nevertheless, it is possible that such trends may exist in some areas at a local scale.

Length of time attended

The length of time the NSW NPWS was in attendance at individual fires varied markedly, from less than one day through to more than two weeks, ultimately being related to the size of the fire. Overall, the attendance at deliberate fires was generally shorter than for natural fires, with both the number (Figure 130) and proportion of deliberate fires decreasing as the attendance duration increased (Figure 131). Nevertheless, 281 deliberate fires occurred over three days to a week, 94 burned for one to two weeks, and a further 80 deliberate fires burned for in excess of two weeks. Natural fires were typically of longer duration, accounting for higher proportions of fires that required fire crew attendance in excess of three days.

The typical time in attendance at deliberate fires varied markedly between regions, reflecting not only the differences in environment, but also the differences in cause. The vast majority of deliberate fires in the Sydney and surrounds region were less than one day, likely a reflection of the higher incidence of small deliberate fires (Figure 132). In contrast, a higher proportion of deliberate fires in the New England Tablelands region burned over a week or more, as there was a tendency for illegal burns offs to result in larger fires (Figure 132). The balance between small and large deliberate fires varied for other regions.

Natural fires that extended over three days were most frequent in the Sydney and surrounds region (Figure 133). Such fires constituted 28 percent of all fires the NSW NPWS attended in the Sydney and surrounds region (Figure 134). In the Northern Rivers region fires of two weeks or longer were fewer (n=7), but accounted for 50 percent of all fires that occurred in that region.

Area burned

Fires the NSW NPWS attended both on- and off-park burned approximately 3.5 million hectares in NSW in the eight years encompassing 1995–96 to 2003–04. Overall, fires varied in size from less than one hectare up to just over 320,000 ha. The number of fires decreased with increasing fire size, although there was a comparatively high number of fires within the 10 to 500 ha range (Figure 135), particularly compared with the NSWFB and NSWRFS. This general distribution was evident across most causal categories. Nevertheless, deliberate causes tended to account for marginally smaller proportions of all fires as fire size increased (Figure 136). In contrast, natural fires accounted for an increasing proportion of fires as fire size increased. This is particularly evident for fires exceeding 5,000 ha.

The greatest total area burned was burned during 2002–03, followed by 2001–02, 2000–01 and 1997–98 (Figure 137). This is in accord with the temporal variations documented for the NSWRFS. In part this reflects the fact both fire services are likely to attend large fires, and large fires dominated total area burned statistics. Notably, three-quarters of the total area burned in fires the NSWRFS attended fires occurred in national parks.

Natural fires accounted for over half the total area burned in fires the NSW NPWS attended within the observation period, being responsible for approximately 80 percent of the total area burned during 1997–98 and 2002–03. Natural fires also burned large tracts of land during 2001–02, but this only accounted for one-third of the total area burned in that year.

Deliberate fires were responsible for 21 percent of the total area burned by fires the NSW NPWS attended (off- and on-park) from 1995–96 to 2003–04. The most extensive occurred during 2000–01, 2001–02 and 2002–03. In 2000–01, the year preceding the Christmas–New Year fires of 2001–02, deliberate fires accounted for approximately 60 percent (289,788 ha) of the total area burned in that year (Figure 137). Deliberate fires burned a further 220,721 ha in 2001–02 and 153,604 ha in 2002–03. Although deliberate fires were typically smaller than natural fires, 94 deliberate fires exceeded 1,000 ha in area; 34 within the 2000 to 4999 ha range, eight in the 10,000 to 49,999 ha range, with a further four burning between 50,000 and 100,000 ha. Of the latter four, two were in the New England Tablelands region (Guy Fawkes National Park), one was in the Sydney and surrounds region (Wollemi National Park) and another occurred in the South Coast and Southern Highlands region (Morton National Park).

The size distribution of deliberate fires varied somewhat depending on the specific cause of the fire. Fires resulting from motor vehicle arson tended to be smaller (Figure 138). Nevertheless, the potential dangers posed by this practice to the environment are evidenced by the fact that the largest burned between 100 and 215 ha. In contrast, fires resulting from illegal burn offs accounted for a disproportionate amount of larger deliberate fires. Thirty-two illegal burn offs burned 1,000 ha or more; the two largest burned 92,719 ha and 71,899 ha in or near the Guy Fawkes National Park (New England Tablelands region) in the 2000–01 season. Fires attributed specifically to arson or suspicious causes ranged from very small to very large. Sixty-four fires of this cause burned 1,000 ha or more, 22 burned 2,000 to 4,999 ha, five burned 5,000 to 9,999 and six burned 10,000 to 49,000 ha. The two largest burned 71,164 ha in the Morton National Park (South Coast and Southern Highlands) in 2002–03 and 82,967 ha in the Wollemi National Park in 2001–02 (Sydney and surrounds region). This is among the highest density of large deliberate fires reported in any jurisdiction in Australia.

The percentage of the total area burned in any one region was largely governed by the regional distribution of very large fires. Approximately, three-quarters of the total area burned in NSW NPWS-attended fires of all causes, from 1995–96 to 2003–04, occurred in three regions; the Sydney and surrounds region, the South Coast and Southern Highlands, and the New England Tablelands (Figure 139). Although the Sydney and surrounds region accounted for a high percentage of all small fires, and comparatively fewer moderate sized fires (500 to 200 ha), it also accounted by a substantial portion of the large fires the NSW NPWS attended (Figure 140). Although the overall proportion was lower, a similar distribution occurs for the South Coast and Southern Highlands region.

In contrast, the New England Tablelands region accounted for a very small percentage of fires of less than 50 ha, but a comparatively high proportion of moderate to large fires. Hence, the New England region accounted for a disproportionately high percentage of the area burned, based on the total number of fires. The Northern Rivers region also accounted for higher proportions of larger fires, but the absence of very large fires (greater than 50,000 ha) meant it did not feature significantly in the total area burned across the state. Similarly, the Hunter–Mid North Coast region accounted for 10 to 30 percent of moderate to large fires, but the total area burned in this region was noticeably less than in the Sydney and surrounds region due to the absence of exceptionally large fires (greater than 50,000 ha).

These general regional trends are also reflected in the size distribution of deliberate fires across regions. Notably, the Sydney and surrounds region accounted for a high proportion of both small and large fires, but accounted for only a small proportion of moderate-sized fires (Figure 141). Both New England and the Northern Rivers regions accounted a higher proportion of larger fires, but accounted for a small proportion of small fires.

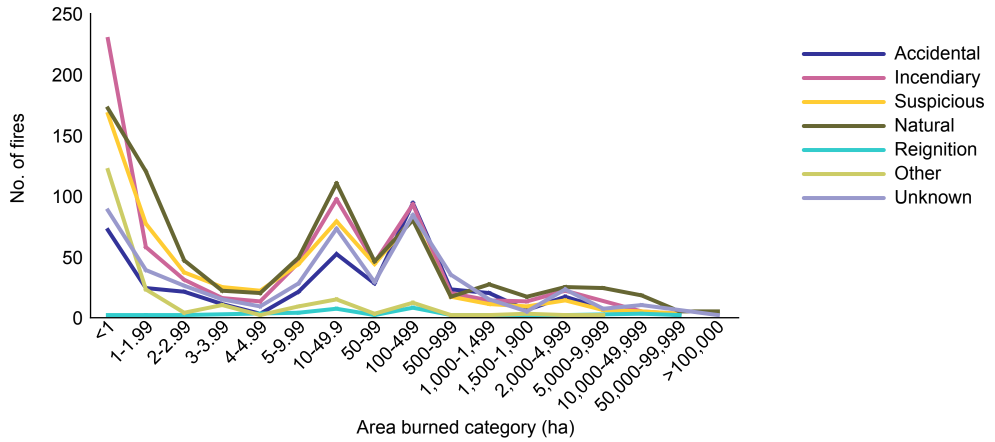
The principal causes of the total area burned are linked to the causes of the largest fires in each region. Natural fires dominate the total area burned in the Sydney and surrounds region, the South Coast and Southern Highlands, Central and Outback NSW.

Deliberate fires accounted for the largest ‘known’ cause of fires in the Hunter and Mid North Coast, New England Tablelands and Northern Rivers regions (Figure 142), burning 95,354 ha, 305,699 ha and 107,213 ha in these region respectively.

The extent to which deliberate fires contribute to the total area burned in each region is largely shaped by the incidence or lack thereof of large natural fires. Although deliberate fires accounted for only 16 percent of the total area burned in the Sydney and surrounds region, they burned 141,722 ha, which represents the second largest area burned by deliberate fires of any one region of the state, behind the New England Tablelands. Similarly, deliberate fires burned 92,104 ha in the South Coast and Southern Highlands, accounting for just nine percent of the total area burned in that region. However, this is comparable to the total area burned in the Hunter and Mid North Coast region during the same interval, a region where deliberate causes were responsible for 30 percent of all land burned.

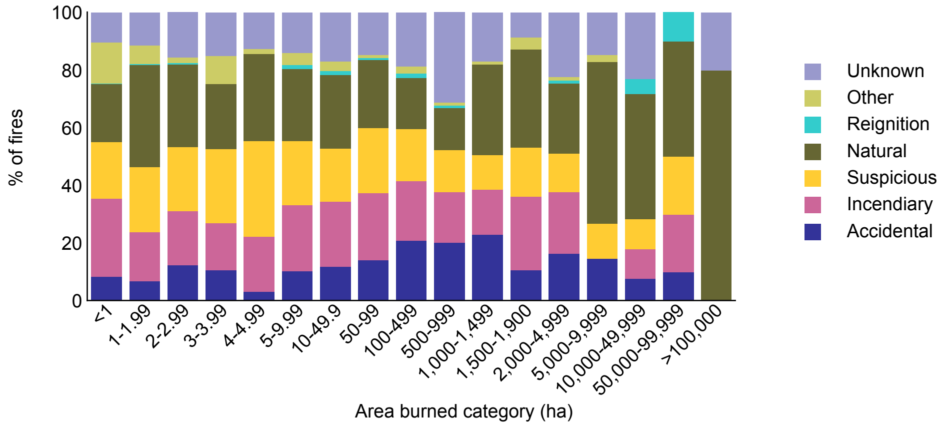
Not surprisingly, fires that started either off-park and spread onto the neighbouring NPWS reserve or started on-park and spread to neighbouring properties accounted for an increasing proportion of all fires as fire size increased; this is because large fires were more likely to transgress property boundaries. Nevertheless, of those fires that did cross boundaries, natural fires were more likely to originate on-park and spread to neighbouring lands (Figure 143), whereas deliberate fires were more likely to start off-park and spread into the park (Figure 144). This has important implications for management of natural reserves in NSW.

Figure 135: Area burned category (ha), by cause (number)



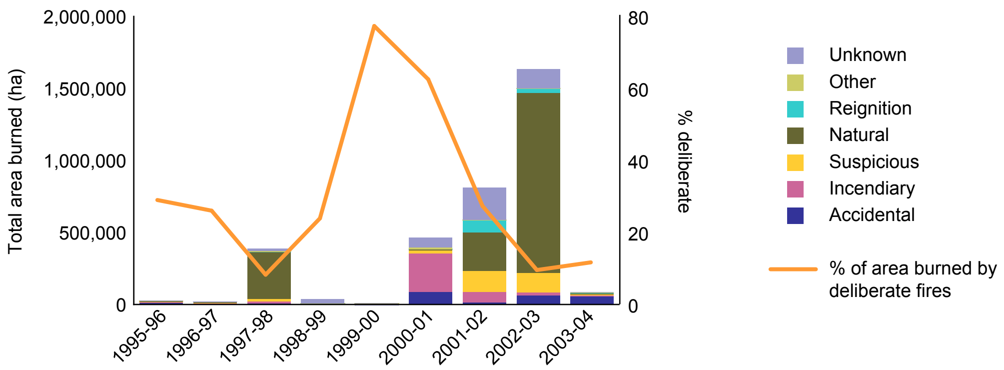
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 136: Area burned category (ha), by cause (percent)



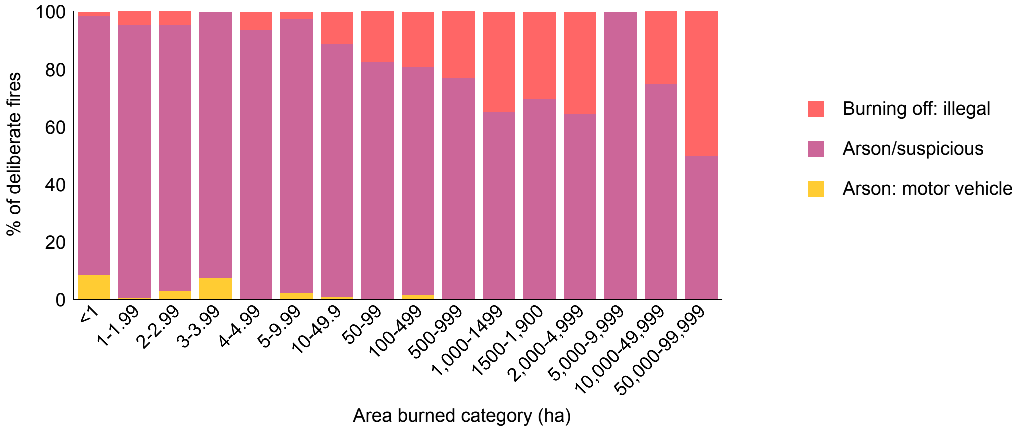
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 137: Total area burned, by cause



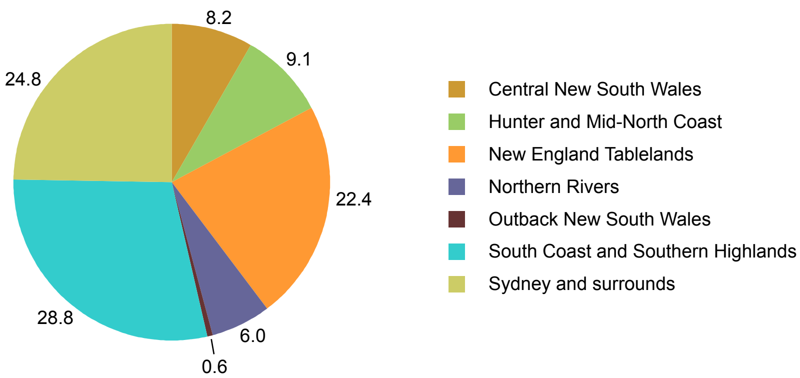
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 138: Area burned category, by specific deliberate causes (percent)



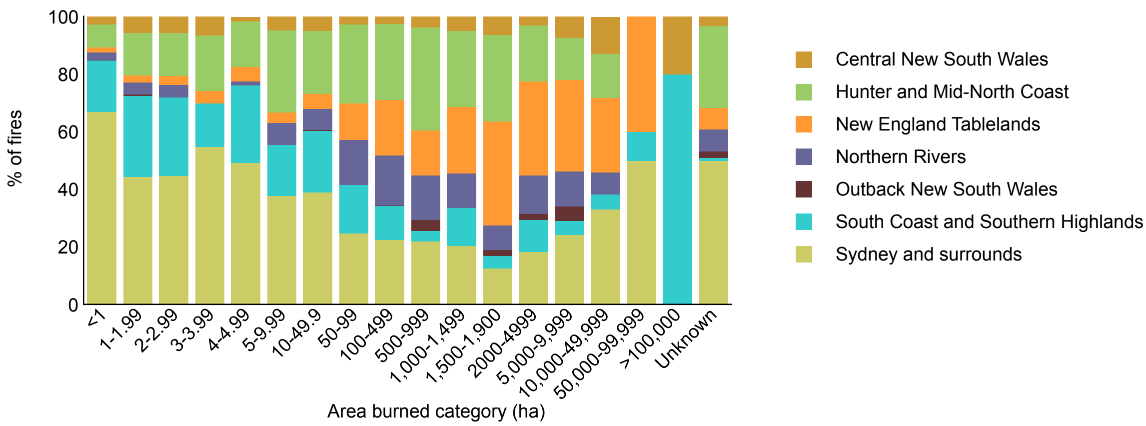
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 139: Total area burned, by region (percent)



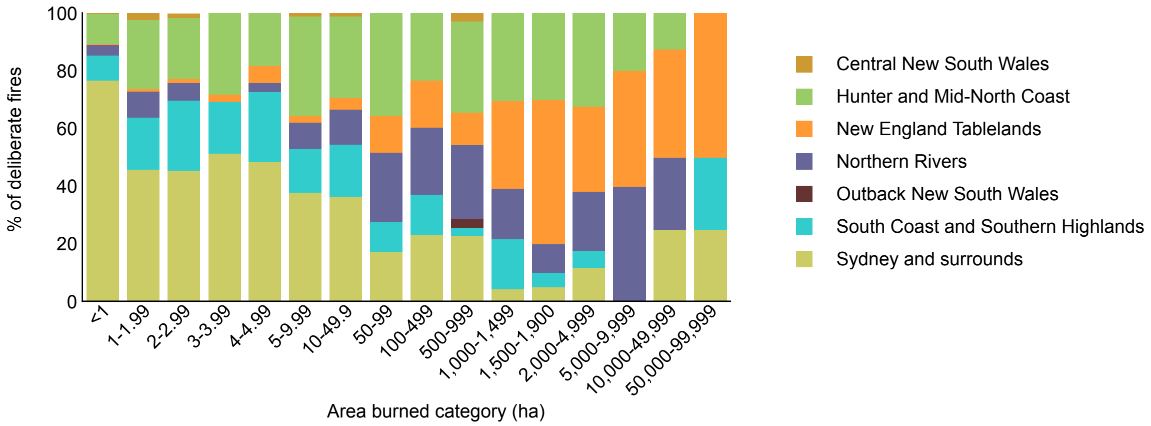
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 140: All vegetation fires, by area burned category and cause (percent)



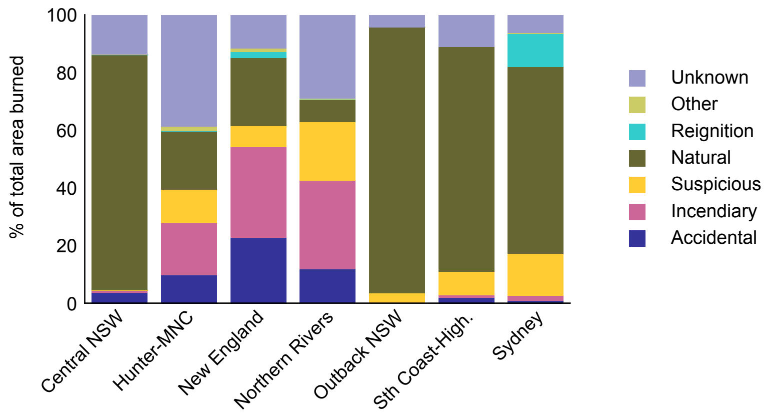
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 141: Deliberate vegetation fires, by area burned category and cause (percent)



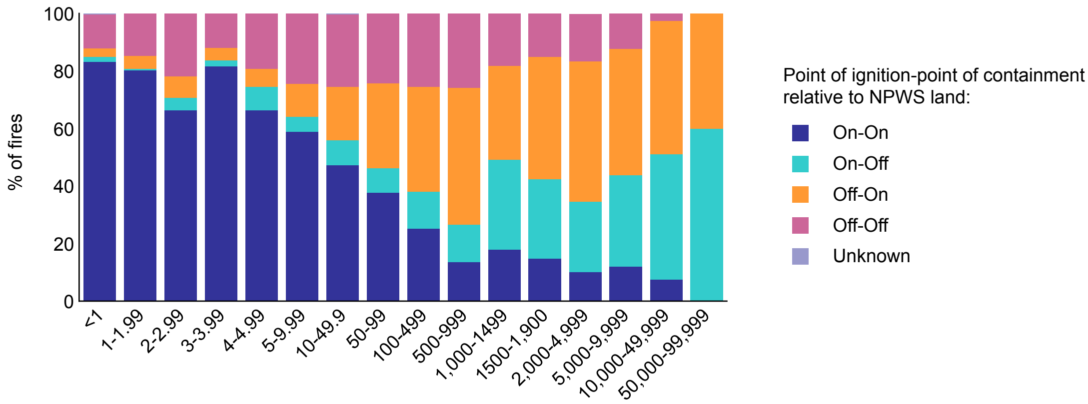
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 142: Total area burned, by cause in each region (percent)



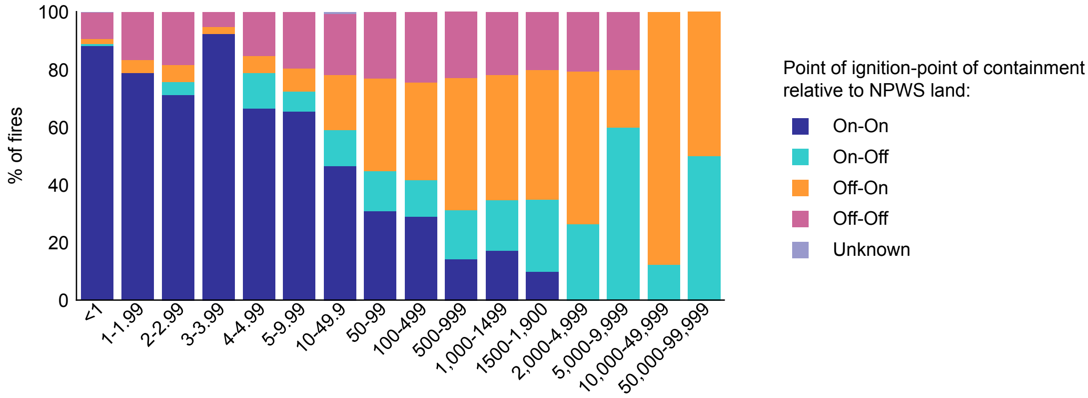
Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 143: Area burned categories for natural fires, by on–off park status (percent)



Source: NSW NPWS 1995–96 to 2003–04 [computer file]

Figure 144: Area burned categories for deliberate fires, by on–off park status (percent)



Source: NSW NPWS 1995–96 to 2003–04 [computer file]

New South Wales State Forests

Background about the SFNSW dataset and its analysis

Important information regarding the SFNSW dataset and the methodology employed to analyse it is outlined below.

- Fire data were sourced from SFNSW.
- The database spans from 1997–98 to 1 December 2003.
- The database does not use AIRS classification codes.
- Cause was defined using the cause variable supplied.
- The terms deliberate and incendiary are used to describe all cases were the causes of the fire was listed as incendiarism.
- All natural vegetation fires were the result of lightning.
- Smoking-related fires refer to all fires where cause (provided) = ‘Pipe, cigarette, match’. All such fires were classified within the ‘other’ causal category.
- The regions used in this analysis are broadly based on those provided by SFNSW (see methodology). These regions do not correspond to those used in the analysis of other NSW fire services databases.
- The dataset included information about the area burned.
- Information was available about the tenure of land on which fires occurred.
- No information was available about the specific time that vegetation burned.
- Only limited information was available about the fire conditions on the day fires occurred, and these variables have not been analysed.

For more detail about these methodologies see the methodology chapter.

Overview

Fires the SFNSW attended can be summarised as follows:

- The SFNSW attended 1,785 vegetation fires from 1997–98 to 1 December 2003. Fire numbers varied between a low of 98 during the 1999–2000 season to a high of 504 during 2002–03 (Figure 145).
- These fires occurred both on and near tenures that lie under the SFNSW's jurisdiction and ranged from small vegetation fires through to large bushfires. Given the role and responsibilities of the SFNSW, it is not unreasonable to assume that most fires it attended either constituted a bushfire, or had the potential to develop into a bushfire under adverse conditions.
- Deliberate causes account for 39 percent of all fires.
- Fires were distributed across the state, but areas that recorded the greatest number of fires included the North Coast, Hunter, Northern Rivers and, to a lesser extent, the South Coast and Snowy Mountains areas. The principal causes if fires attended varied markedly between regions. Deliberate fires were an important factor in fires attended in the Hunter and Mid North Coast, South Coast and, to a lesser extent, the Northern Rivers and Explorer Country regions.
- A total of 1,327,009 ha were burned in fires the SFNSW attended from 1997–98 to 2002–03; approximately 22 percent of this was burned by deliberate fires. Deliberate causes were a critical factor in the total area burned in 2001–02.

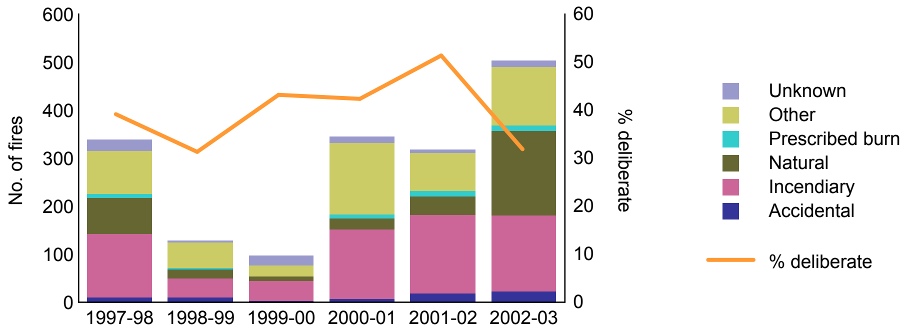
Cause

Deliberate fires accounted for 39 percent of all fires the SFNSW attended, being the single largest causal category (Figure 146). The number of deliberately lit fires varied markedly between seasons. The SFNSW typically observed between 130 and 160 deliberate fires per year, but substantially lower numbers of deliberate fires occurred during both the 1998–99 and 1999–2000 seasons. In any one year deliberate causes accounted for 31 to 51 percent of all fires. The peak occurred during the 2001–02 season (Figure 145).

Natural fires accounted for 20 percent of fires attended (Figure 146). The highest number and proportion of natural fires occurred during 2002–03 (35%) and, to a lesser extent, 1997–98 (22%). In non-El Niño seasons natural fires comprised six to 15 percent of fires.

Fires classified as 'other' constituted 30 percent of fires the SFNSW attended (Figure 146). Almost two-thirds of 'other' fires were burn offs (rural burns). Rural burns were a major factor in higher numbers of fires in 2000–01 (Figure 147), contributing to 31 percent of fires in that region. Smoking-related materials accounted for only 1.3 percent of fires the SFNSW attended, with the highest numbers (n=11) occurring during 2002–03.

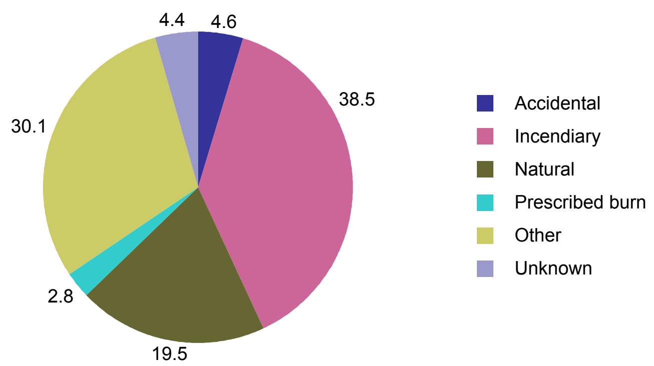
Figure 145: Cause, by year[a]



a: a prescribed burn refers to all burns conducted by a prescribed authority (listed as SF PB, DBFS PB and Burning-other PA), but excludes rural burns, even though some of those burns may have legal and considered a prescribed burn

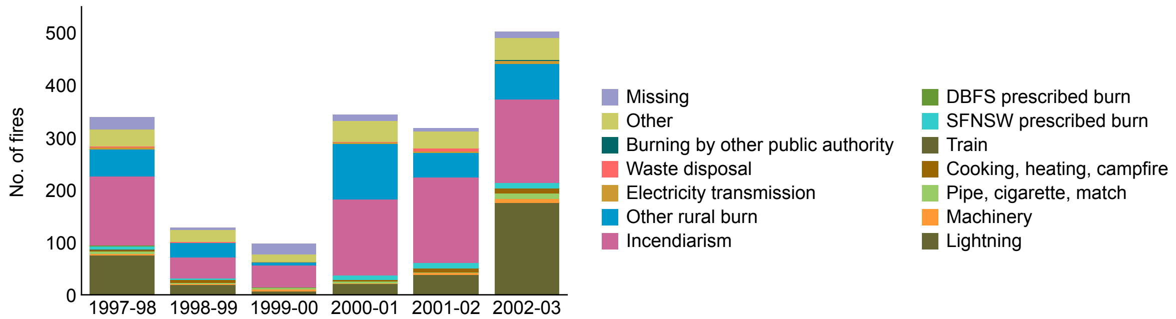
Source: SFNSW 1997–98 to 2002–03 [computer file]

Figure 146: Cause (percent)



Source: SFNSW 1997–98 to 1/12/2003 [computer file]

Figure 147: Specific cause, by year (number)



Source: SFNSW 1997–98 to 2002–03 [computer file]

Location

The location of SFNSW-attended fires is examined in terms of the region and reserve in which fires occurred and the tenure of those lands.

Region

The definitions of regions used in this analysis are based on but have been modified from those provided by SFNSW, and differ from those used in the analysis of other NSW fire service databases. Important points about the regional distribution of fires the SFNSW attended are summarised below.

North Coast: Almost one-third of all SFNSW-attended fires occurred in the North Coast region (Figure 148). This remained comparatively consistent over the observation period (Figure 149). Approximately 54 percent of fires on the North Coast occurred in the Coffs Harbour district, with a further 29 percent being located near Wauchope.

Fifty-four percent of fires occurring in the North Coast region were the result of deliberate lightings (Figure 150). A higher number of deliberate fires occurred during the latter half of the observation period, with the maximum occurring during 2002–03 (Figure 151). The highest proportion of deliberate fires (77%) occurred during the 2001–02 season. The greatest number and proportions of natural fires occurred on the North Coast in 2002–03 and 1997–98.

Hunter: Nineteen percent of SFNSW-attended fires occurred in the Hunter region (Figure 148). However, the proportion of fires occurring in this region each year steadily declined in the latter half of the observation period (Figure 149). This does not reflect a net decrease in fire incidence; rather the changes in the Hunter region have not kept pace with that occurring statewide. The highest number of fires occurred in 1997–98.

Deliberate fires were again a major cause of fires in the Hunter region (47% of all fires; Figure 150), and from 1999–2000 to 2001–02 deliberate fires accounted for 54 to 62 percent of all fires. The highest incidence of deliberate fires occurred in 2001–02, but high values were also documented for 1997–98 and 2000–01. This is comparable to the trends other fire agencies documented for the Hunter region. Increased numbers and higher proportions of natural fires occurred for both 1997–98 and 2002–03.

Northern Rivers: Sixteen percent of SFNSW-attended fires occurred in the Northern Rivers region, principally within the Casino district. Large discrepancies were evident between the first and second halves of the observation period; average number of fires jumped from 14 fires per year for 1997–98 to 1999–2000 to 69 fires per year for 2000–01 to 2002–03. Between 2000–02 and 2002–03 almost one-quarter of all fires the SFNSW attended occurred in the Northern Rivers region. The greatest number of fires occurred during 2000–01 (Figure 153), accounting for 30 percent of all fires the SFNSW attended in that year (Figure 149).

Factors underlying these temporal changes are complex. A higher number of natural fires occurred in 2002–03 relative to 1997–98 (Figure 153), and higher frequencies of deliberate fires occurred from 2000–01 and 2002–03. Deliberate fire frequencies peaked in 2000–01, but subsequently decreased over the following two years. However, deliberate firesetting cannot be singled out, as the proportion of fires resulting from this cause (30 to 35%) was in fact lower than during the previous three years; deliberate causes were just one of many factors contributing to increased fire numbers in this region. One critical factor to have changed was the increase in fires resulting from rural burns. Overall there was a four-fold increase in the number of rural burns, and in 2000–01 rural burns were responsible for 54 percent of all fires attended in the region. Surprisingly, the percentage of fires resulting from rural burns was not appreciably different to previous years (Figure 153).

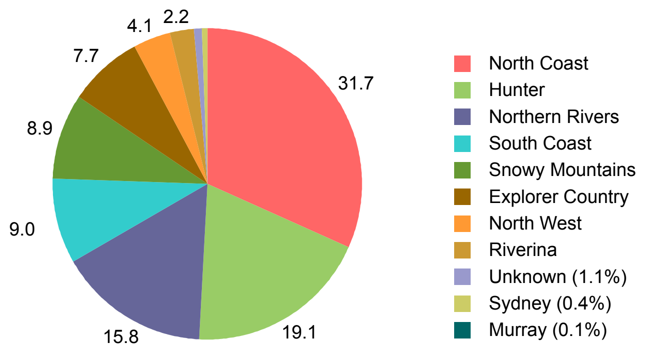
Other regions: The Explorer Country, Snowy Mountains and South Coast regions each accounted for eight to nine percent of fires the SFNSW attended. The SFNSW attended comparatively fewer fires in the North West, Riverina or Sydney and surrounds regions. To a certain extent this reflects the distribution of lands over which the SFNSW has jurisdiction.

Between 50 and 60 percent of fires in the Snowy Mountains and North West regions resulted from natural fires. Higher proportions of fires in the South Coast, Explorer Country and Riverina also resulted from natural causes. The number and proportion of deliberate fires was lower in areas characterised by low total fire numbers.

Comment

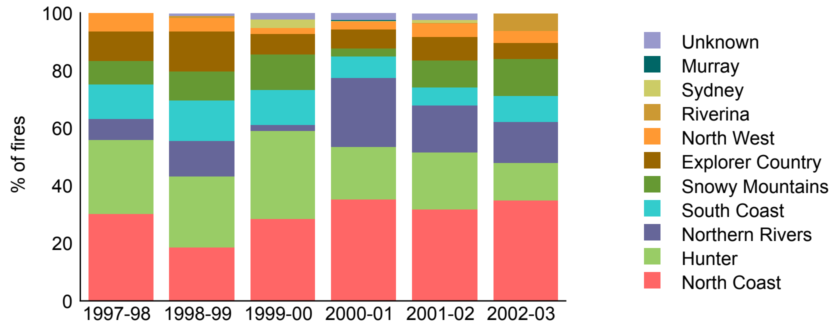
Virtually all regions in NSW were characterised by a higher number of natural fires in 2002–03 and to a lesser extent 1997–98 when compared to the intervening years (Figure 154). In both instances, higher numbers of natural fires were associated with extensive drought conditions, brought about by El Niño or El Niño-like weather patterns in the Pacific. Regions that appeared most affected included the Snowy Mountains, the North and South Coast and the Northern Rivers. Greater numbers of natural fires in 2002–03 compared to 1997–98 may reflect more severe drought conditions, with the 2002–03 droughts having followed comparatively dry seasons in both 2000–01 and 2001–02.

Figure 148: All fires, by region (percent)



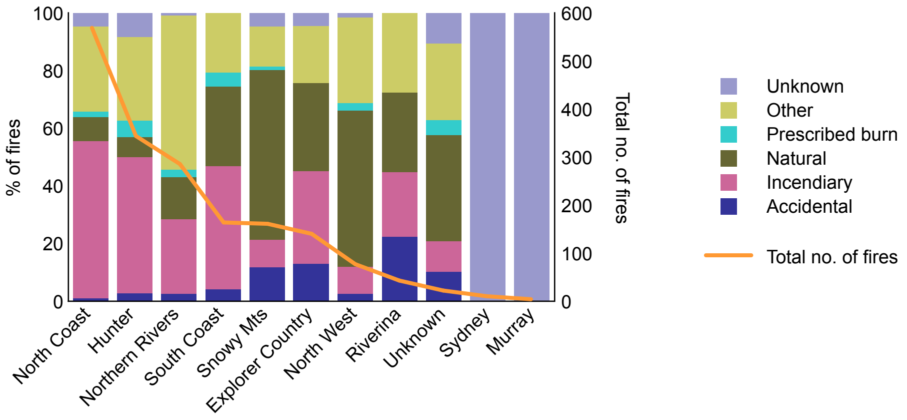
Source: SFNSW 1997–98 to 1/12/2003 [computer file]

Figure 149: Year, by region (percent)



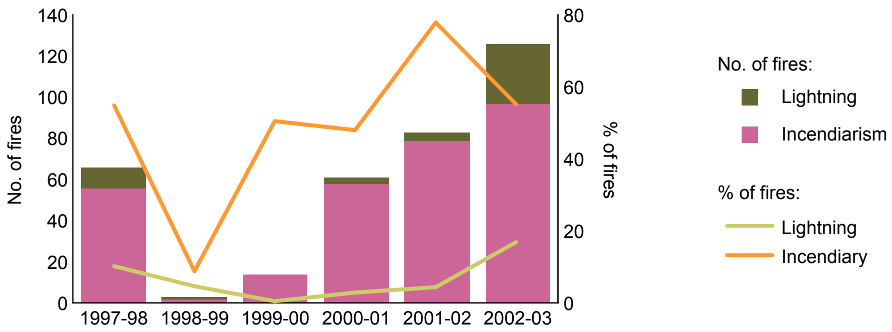
Source: SFNSW 1997–98 to 2002–03 [computer file]

Figure 150: Cause, by region (percent)



Source: SFNSW 1997–98 to 2002–03 [computer file]

Figure 151: Deliberate and natural fires in the North Coast region, by year

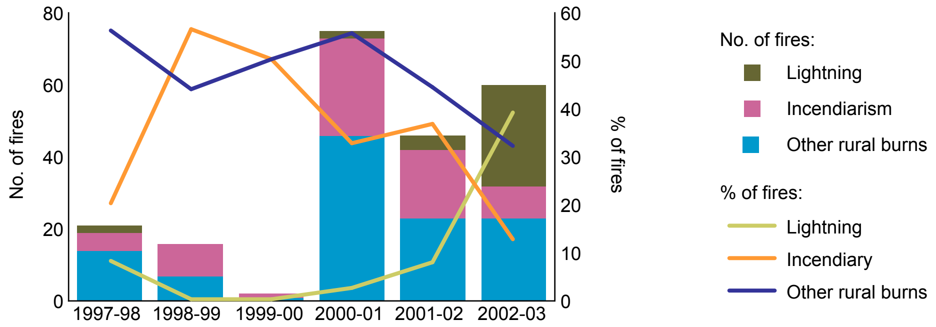


Source: SFNSW 1997–98 to 2002–03 [computer file]

Figure 152: Deliberate and natural fires in the Hunter region, by year

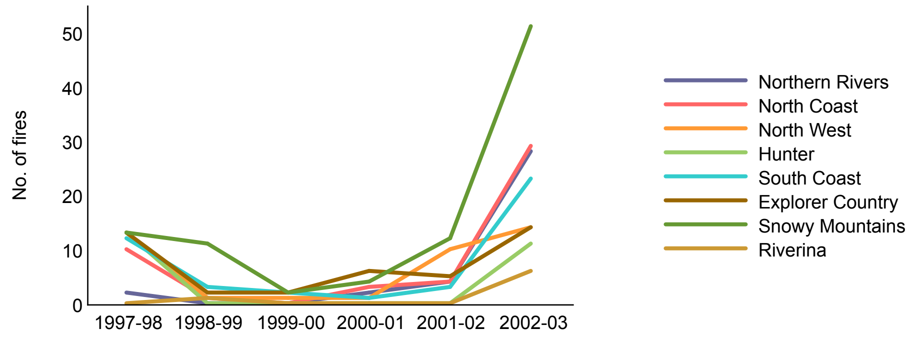
Source: SFNSW 1997–98 to 2002–03 [computer file]

Figure 153: Deliberate, natural and rural burns in the Northern Rivers region, by year



Source: SFNSW 1997–98 to 2002–03 [computer file]

Figure 154: Natural fires, by region and year



Source: SFNSW 1997–98 to 2002–03 [computer file]

Reserves

The 1,785 fires the SFNSW attended occurred on more than 370 reserves. Four reserves, including the Awaba, Olney and Aberdare state forests in the Hunter region and the Bago State Forest in the Snowy Mountains region, experienced between 25 and 50 fires (Figure 155). A further 39 forests recorded between 10 and 24 fires in the six-year period. Of these, 17 were in the North Coast region, nine in the Northern Rivers region, five each in the Hunter and South Coast regions, two in the North West region and one in the Explorer Country region.

Overall, the tendency for a reserve to experience a deliberate fire was positively correlated (r=.83; p<.01) with the percentage of deliberate fires; if there was a high proportion of deliberate fires within a region, there was a greater probability that a reserve in that region would be the subject of a deliberate firesetting incident. On average, 77 percent of fires were deliberate in reserves that experienced 10 or more deliberately lit fires in six years. On average 66 percent of fires were deliberate in reserves that experienced five to nine deliberate fires in six years.

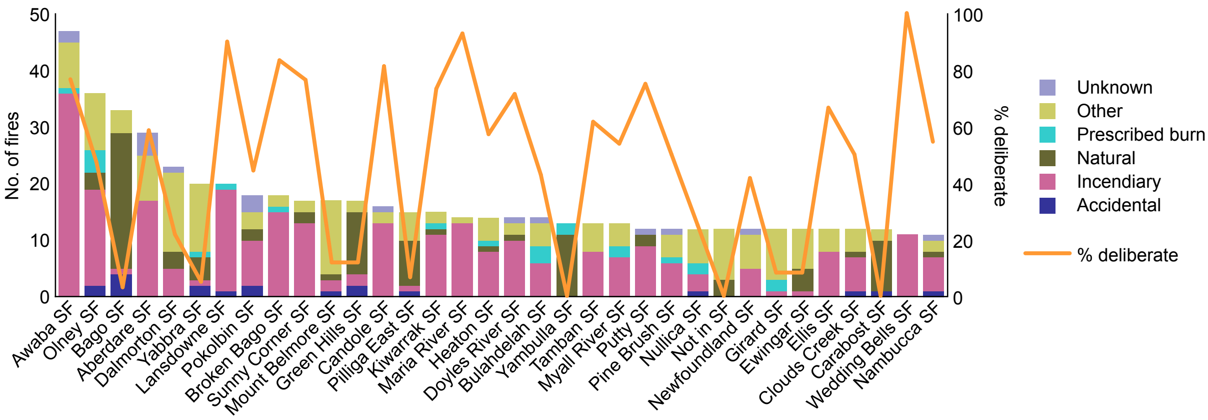
One or more deliberate lightings occurred in 70 and 75 percent of reserves in the North and South Coast regions where a fire was observed. In the Hunter the value was 60 percent. Only 20 to 30 percent of reserve in the Snowy Mountains, Riverina and the North West regions that experienced a fire, also reported a deliberate fire.

However, reserves in the Hunter regions experienced a greater density of deliberate fires. Thirty-six deliberate fires were set in the Awaba State Forest, more than double that of any other reserve in NSW. Seventeen deliberate fires were also recorded in the Olney and Aberdare State Forests. Three of the top four reserves, in terms of the number of deliberate fires, were in the Hunter region (Figure 156).

A high number of deliberate fires also occurred in many North Coast reserves. Seven of the eleven reserves that documented 10 deliberate fires or more occurred in the North Coast region; Lansdowne and Broken Bago recorded 15 to 18 deliberate fires, and another five reserves documented 10 to 14 deliberate fires.

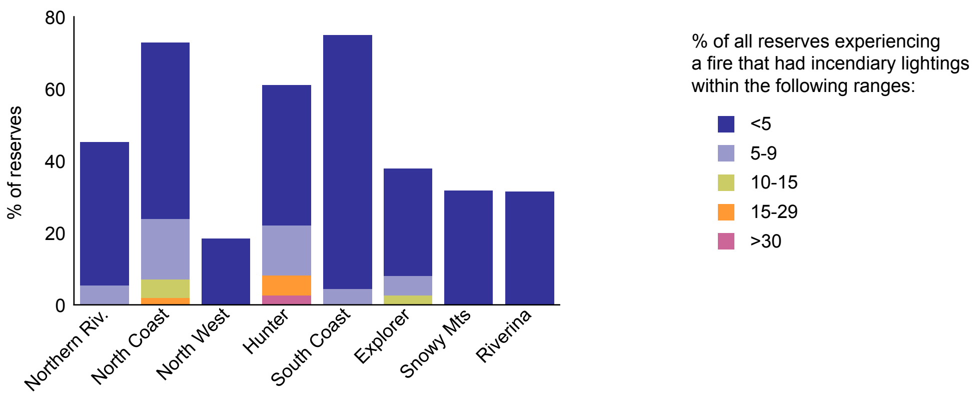
Few reserves in the South Coast or the Northern Rivers experienced a high density of deliberate fires. Fires in these regions tended to be spread across many different reserves.

Figure 155: Reserve, by cause



Source: SFNSW 1997–98 to 1 December 2003 [computer file]

Figure 156: Concentration of deliberate fires in reserves within each region



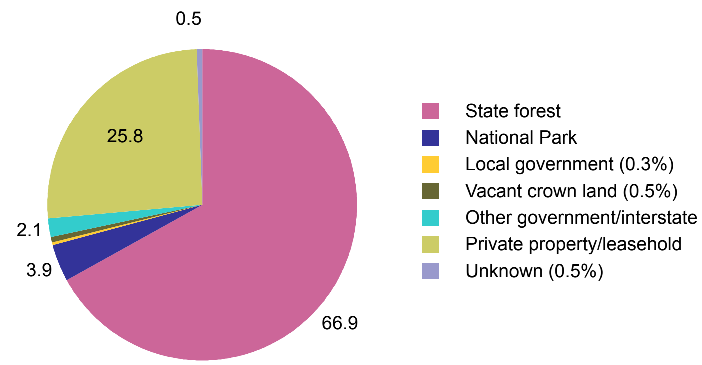
Source: SFNSW 1997–98 to 1 December 2003 [computer file]

Tenure

Two-thirds of the fires the SFNSW attended occurred on state forest tenure, with another quarter occurring on private leasehold land (Figure 157). Only 3.9 percent of fires the SFNSW attended started in national parks.

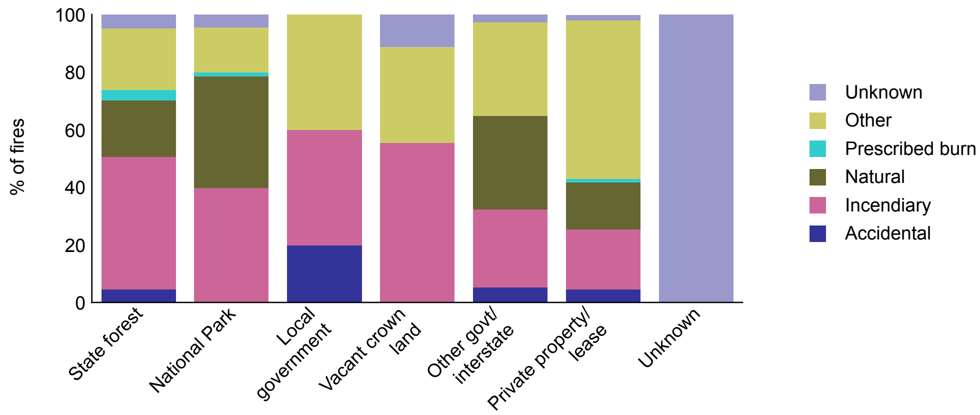
Almost half of the fires that started in state forests resulted from incendiary activities (Figure 158). High proportions of fires in national parks, on local government lands, and vacant Crown land were also deliberate in origin. Natural fires accounted for a higher proportion of fires in national parks, whereas 'other' causes (commonly rural burns) were most significant on private property and leasehold land.

Figure 157: Tenure (cause)



Source: SFNSW 1997–98 to 1 December 2003 [computer file]

Figure 158: Cause, by tenure (percent)



Source: SFNSW 1997–98 to 1 December 2003 [computer file]

Timing

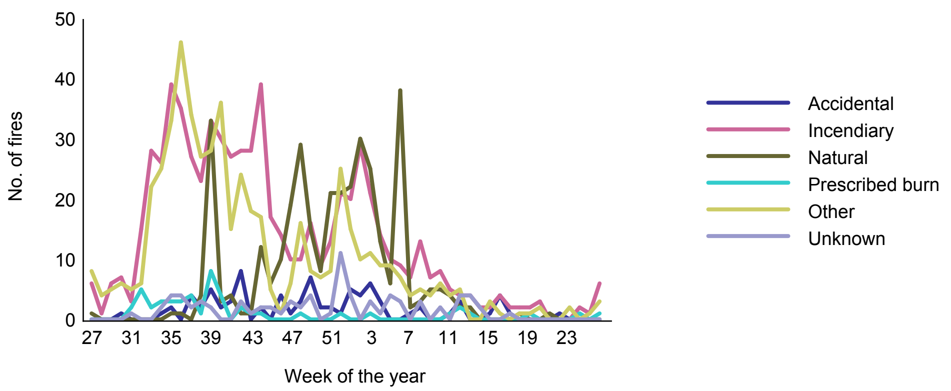
The timing of fires is examined by week of the year, day of the week and time of the day.

Week of the year

The distribution of fires throughout the year in NSW state forests was highly cause-dependent (Figure 159), with trends being similar to that observed for the NSW NPWS data. Natural fires tended to peak within a one- or two-week period, although both the intensity (number of fires) and timing of natural fires varied substantially across seasons, generating a spiked pattern overall. During 'normal' years (years not associated with an El Niño-like weather pattern) the maximum number of natural fires that occurred within any one week was low. In these seasons, most natural fires occurred between mid to late December and mid to late February. In contrast, large spikes in natural fire activity occurred every three to five weeks during 2002–03, from the beginning of October to the middle of March (Figure 160). Excluding the early October spike, the numbers of natural fires tended to increase as the summer progressed. Large peaks in natural fires also occurred in 1997–98, but in contrast to 2002–03 the maximum number that occurred in each peak decreased as the summer progressed. Fires started by lightning occurred markedly earlier in 2002–03, and to a lesser extent in 1997–98, as compared with years not associated with an El Niño event.

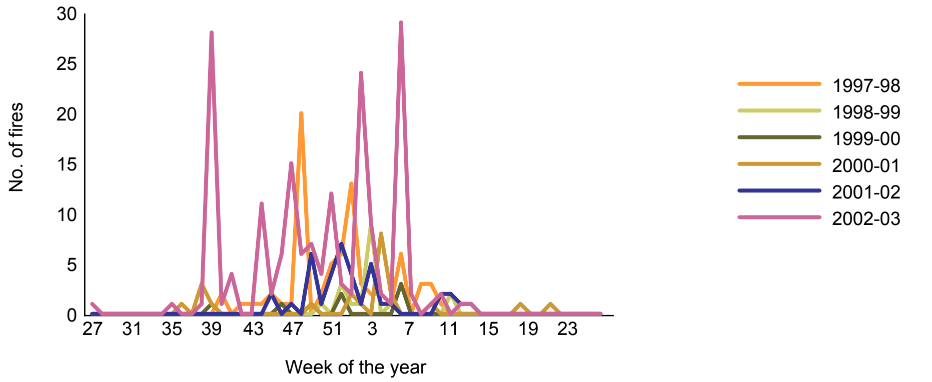
As observed for other NSW fire agencies, deliberate fires the SFNSW attended defined two distinct spikes; one from mid August to mid November, the other in December–January (Figure 159). However, like natural fires, the distribution of deliberate fires varied significantly between years, being subject to yearly variations in weather conditions. Higher rainfall during the winter, spring and to a lesser extent summer of 1999–2000 was associated with low incidences of deliberate fires across that year (Figure 161). In 2000–01, a large spike in deliberate fires occurred in September and October, only being curtailed by high rainfall in November. This was the most intense period of deliberate firesetting observed in SFNSW data over the six-year period. Two peaks were evident during the subsequent 2001–02 season. One was during weeks 42 to 44 (mid October to early December), coinciding with the period during which seven 'bushfire emergencies' were declared around Cessnock, Gosford, Gloucester, Kempsey, Wyong, Greater Taree and Singleton (29 October to 9 November; NSWRFS 2001). The second period occurred from weeks 52 to 2, coincident with the devastating Christmas–New Year fires. During 2002–03, spikes in deliberate fires occurred from mid August (prior to increased natural fire activity) to almost the end of January. Again, somewhat disturbingly, increased numbers of deliberate fires were observed during the third week of January when bushfires devastated much of the Southern Tablelands and the ACT. Nine fires were deliberately lit in NSW state forest in the two weeks after the Kosciouszko–Canberra fires. Six of those occurred in the Taree region and two in the Coffs Harbour region.

Figure 159: Week of the year, by cause (number)



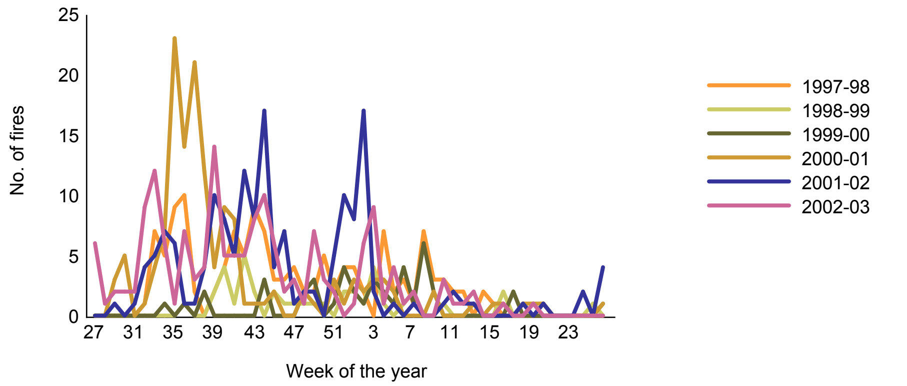
Source: SFNSW 1997–98 to 2002–03 [computer file]

Figure 160: Natural fires, by week of the year each year (number)



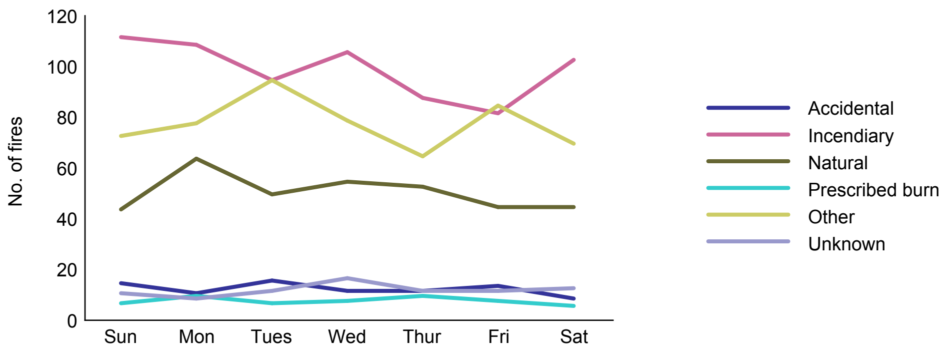
Source: SFNSW 1997–98 to 2002–03 [computer file]

Figure 161: Deliberate fires, by week of the year each year (number)



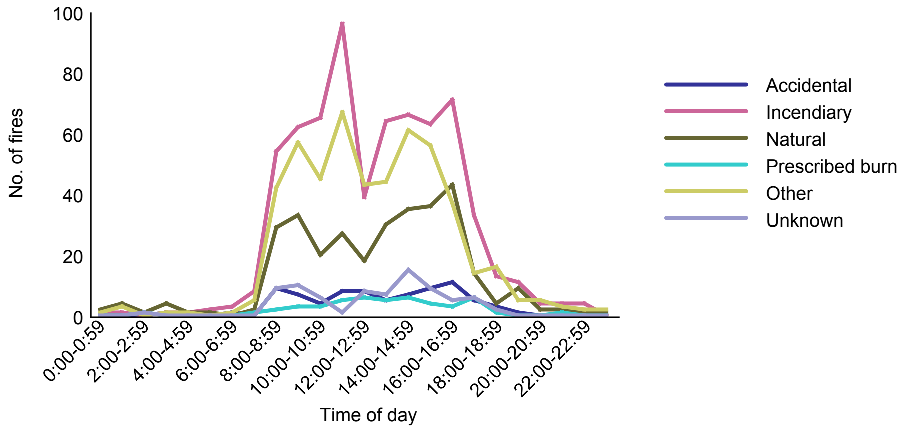
Source: SFNSW 1997–98 to 2002–03 [computer file]

Figure 162: Day of the week, by cause (number)



Source: SFNSW 1997–98 to 1 December 2003 [computer file]

Figure 163: Time of day, by cause (number)



Source: SFNSW 1997–98 to 1 December 2003 [computer file]

Day of the week

There was no perceptible difference in the number of fire lit on weekends versus weekdays, irrespective of the cause (Figure 162).

Time of the day

The overwhelming majority of fires the SFNSW attended were detected between the hours of 8 am and 6 pm (Figure 163). This was observed irrespective of cause, although some bias toward later times was evident for natural fires. The latter is consistent with observations from other agencies. However, the sharp increase and decrease in fire incidence at 8 am and 6 pm respectively and the consistent decrease in the number of fires reported between 12 and 1 pm (lunch time), implies that the detection times reported for SFNSW-attended fires were affected by the routines of workers as they moved within or through these region and to some extent may not accurately reflect the exact times of ignition. Many fires that started at night may not have been observed and/or reported until the following day.

Area burned

Overall, there was a tendency for the number of fires to decrease with increasing fire size, but the relationship was less systematic in SFNSW data than that observed for many other agencies. In particular, the SFNSW recorded a higher proportion of medium and large fires than other NSW fire agencies (Figure 164), but this is not an uncommon size distribution for a land management agency given the environments in which fires occur.

This general distribution was evident across all causes, but some differences were evident in size distributions based on cause. The proportion of fires stemming from ‘other’ causes tended to increase with increasing fire size, reflecting the fact that many of the larger fires were the result of rural burns. However, this category does also include other fires of unspecified causes. A high proportion of large fires also resulted from lightning strikes. However, not all fires started by lightning strikes were large. Contrary to observations elsewhere, natural fires also accounted for a substantial proportion of small fires the SFNSW attended.

The proportion of fires resulting from deliberate causes tended to decrease with increasing fire size (Figure 165), but incendiary causes were still responsible for a number of very large fires the SFNSW attended. The incidence of large deliberate fires appeared to be restricted to specific seasons. During 1998–99 and 1999–2000, years characterised by milder conditions, fire sizes were comparatively small, with no deliberately lit fires exceeding 1,500 ha (Figure 166). In all other years a high proportion of fires were in the five to 1,500 ha range. Eight deliberately lit fires exceeded 5,000 ha; all occurred during 2001–02 and 2002–03. Specifically:

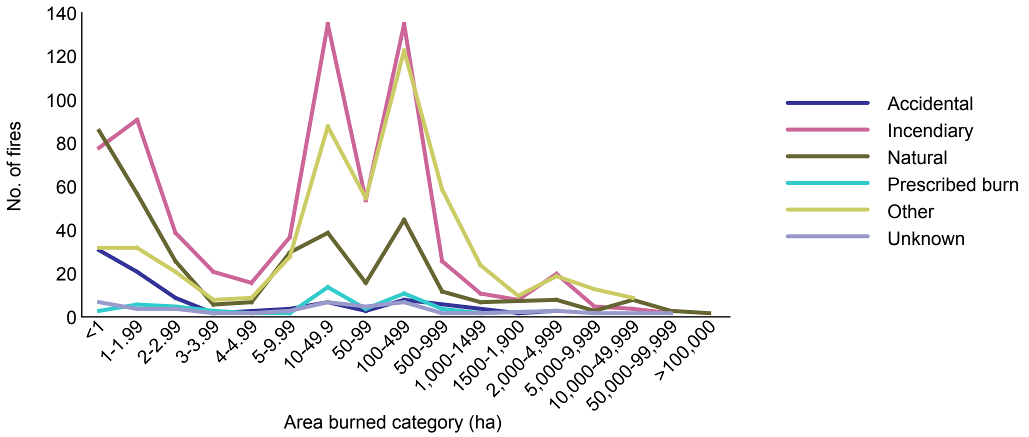
- During **2001–02** four deliberate fires exceeded 5,000 ha. The largest burned 81,133 ha near Newcastle. Three of the five largest deliberately lit fires during this season occurred near Casino (Northern Rivers region), the largest burning 31,800 and 8,694 ha. Another deliberately lit fire during this season burned 20,500 ha near Wauchope. All four deliberately fires greater than 5,000 ha in this season occurred either just before or during the Sydney 2001–02 Christmas fires. The incidence of deliberate firesetting during adverse fire periods is discussed in further detail below.
- In **2002–03**, four deliberate fires exceeded 5,000 ha. Three of these occurred in the Coffs Harbour region, burning 5,140 ha, 5,296 ha and 10,207 ha respectively. Another deliberately lit fire burned 6,500 ha near Newcastle. These four fires occurred within a six-week period comparatively early in the fire season between weeks 37 and 42, prior to the large fires in southern NSW in January.

A total of 1,327,009 ha burned in SFNSW-attended fires from 1997–98 to 2002–03. The largest total area was burned in 2002–03, followed by 2001–02 (Figure 167). However, the predominant cause(s) of the area burned varied markedly between years:

- In both 1997–98 and 2002–03, years where there was a greater incidence of fires started by lightning strikes, **natural fires** accounted for 85 and 47 percent of the total area burned, respectively.
- In 2000–01, fires of **other** causes burned 130,860 ha, accounting for 78 percent of total area burned in that season. Two-thirds of the area burned by other causes was the result of rural burns.
- In 2001–02, **incendiarism** was the largest single contributor to the total area burned, with natural causes accounting for approximately one-fifth of the total area. Other causes burned over 40,000 ha in 2001–02 but this accounted for only 11 percent of the total area burned.
- The total area burned by **deliberate fires** in 2002–03 was lower than that burned in 2001–02, but the area burned by ‘other’ causes was substantially higher. Fires of other causes burned almost 200,000 ha during 2002–03, of which half related to rural burns. Thirteen rural burns in that year exceeded 5,000 ha. Five of these occurred in the Casino region with an additional five occurring in the Coffs Harbour district. The largest rural burn was 30,524 ha.

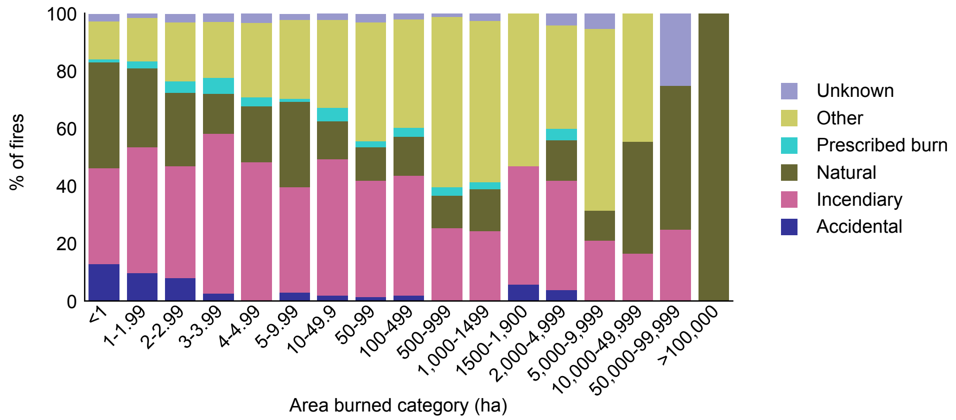
Forty-six percent of the total area burned in fires the SFNSW attended occurred in state forests, 29 percent in national parks, and 21 on private property or leasehold land (Figure 168). Of that burned in state forests, approximately one-third resulted from deliberate causes (Figure 169). Another third each resulted from natural and other causes. Natural fires were the dominant cause of the total area burned by fires the SFNSW attended in national parks. Not surprisingly, the majority of the total area burned on private property and leaseholds resulted from other causes, with rural burns being a major factor. Accidental causes were primarily responsible for lands burned in local government jurisdictions, whereas deliberate causes were responsible for the majority of the total area burned on ‘other government lands/ interstate’ tenures.

Figure 164: Area burned categories, by cause (number)



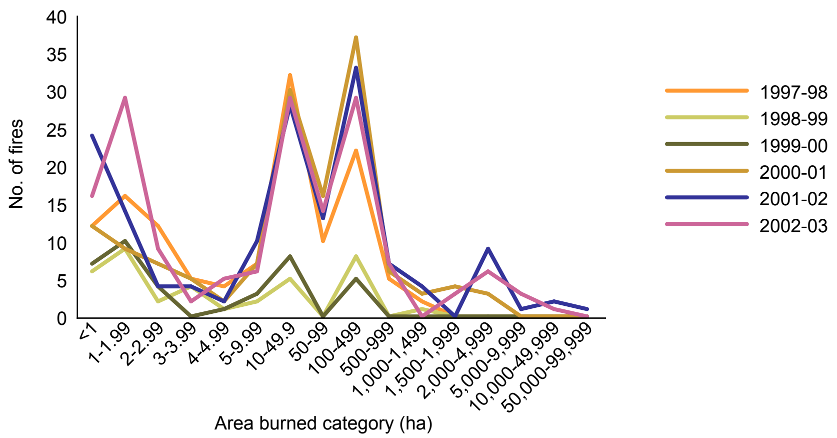
Source: SFNSW 1997–98 to 2002–03 [computer file]

Figure 165: Area burned categories, by cause (percent)



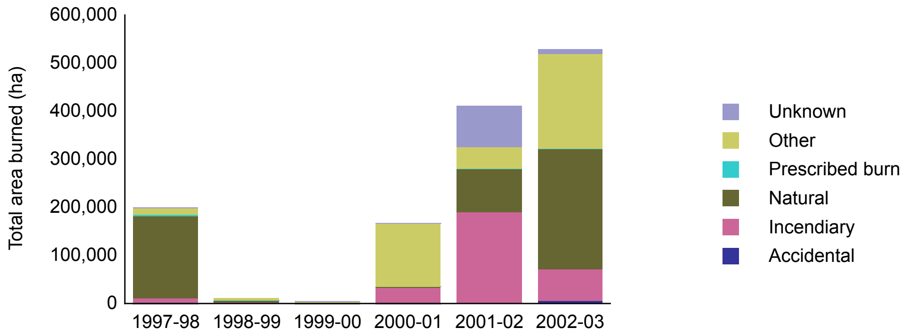
Source: SFNSW 1997–98 to 2002–03 [computer file]

Figure 166: Area burned categories for deliberate fires, by season (number)



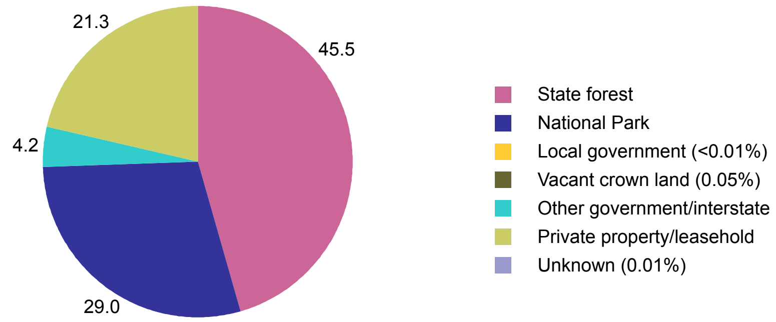
Source: SFNSW 1997–98 to 2002–03 [computer file]

Figure 167: Total area burned (ha), by cause in each season (number)



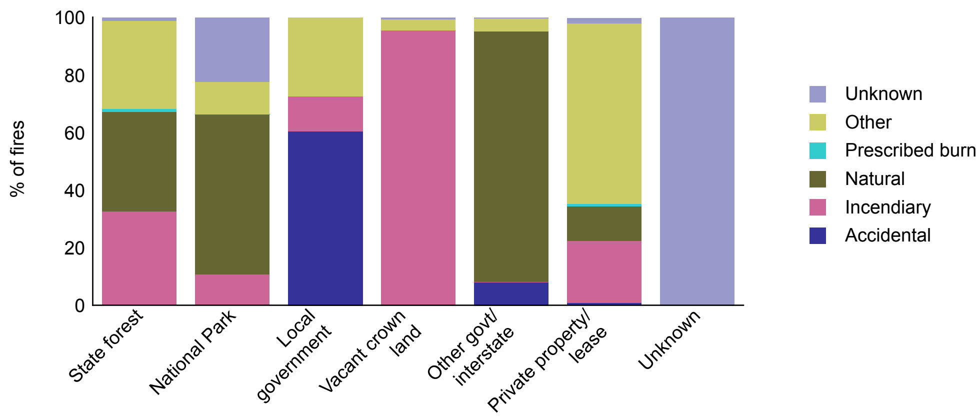
Source: SFNSW 1997–98 to 2002–03 [computer file]

Figure 168: Total area burned, by tenure (percent)



Source: SFNSW 1997–98 to 2002–03 [computer file]

Figure 169: Total area burned, by cause within each tenure category (percent)



Source: SFNSW 1997–98 to 2002–03 [computer file]

Regional distribution of vegetation fires in NSW: combined NSWRFS and NSWFB data

This section analyses the combined NSWRFS and NSWFB data for the total fire numbers and the number of deliberate fires during 2000–01 and 2001–02. These were the only years for which data was available from both agencies.

Total fire numbers

Only one postcode in NSW experienced in excess of 1,000 fires in two years. This occurred in the Campbelltown SLA. Another four postcodes, recorded 500 to 1,000 fires. Of these, two were in metropolitan areas (Blacktown–South West and Liverpool SLAs) and two were in regional areas (Kempsey and Moree Plains SLAs). These postcodes collectively accounted for 12 percent of all fires the NSWRFS and NSWFB attended. Approximately one-fifth of all fires in the state occurred in the 11 postcodes that recorded between 300 and 499 fires, and another 22 percent occurred in the 28 postcodes that recorded 100 to 199 fires in two years.

Of the 44 postcodes that recorded in excess of 200 fires, 16 were located in the Sydney region, with the remainder being spread throughout regional NSW (Table 5). The North Coast and Hunter regions recorded the largest number of postcodes with greater than 200 fires in two years outside the metropolitan area. Fire frequencies of this magnitude were almost exclusively restricted to urban areas; of the 44 postcodes recording in excess of 200 fires all but three had populations exceeding 10,000 people and 32 contained more than 20,000 people.

Population size clearly has a significant impact on the number of fires experienced within a given postcode, and population densities within individual postcodes vary markedly across the state. Individual postcodes have populations ranging from just over 100 to greater than 80,000 people.

The minimum recorded rate of fires per 10,000 people per year decreased with increasing population for individual postcodes, being governed by a single fire event in the two-year interval. Hence, the minimum observed rate decreases within increasing population size. There is no such restriction on the maximum rate of fires per 10,000 people per year. This rate remained comparatively uniform across postcodes with high divergent population densities (Figure 170). Hence, the range of rates observed tends to be greatest in densely population, urban, areas. Overall, NSW postcodes typically recorded between one and 300 fires per 10,000 people per year (Figure 170). However, higher values were recorded in six regional postcodes, within the Brewarrina, Bourke, Great Lakes, Gunnedah and Guyra SLAs. The maximum rates of fires per person tended to be on the high side when compared with some other states. However, these figures may not be representative of the long-term average given that 2000–01 and 2001–02 were both characterised by higher than average numbers of deliberate fires.

Although 36 percent of all NSWFB- and NSWRFS-attended fires occurred in the Sydney region, the majority of Sydney postcodes recorded fewer fires per person per year than postcodes in regional areas (Figure 170). The highest rates observed in the Sydney region were comparable to typical values observed in regional areas. This is not unexpected given the higher population density, more restricted access to vegetation, and commonly small areas covered by urban postcodes. This general difference between the numbers of fires per person per year was noted for regional and metropolitan Victoria. It is noted, however, that several postcodes within the Blue Mountains, Illawarra and Hunter regions with in excess of 8,000 people also recorded lower rates of fires on a per person basis.

Postcodes within individual regions recorded highly diverse rates of fires on a per person basis and there were large overlaps in the rates observed in regional areas. Generally, the average rate tended to remain comparatively constant across postcodes with highly varying population sizes, but there were some exceptions. In regional areas experiencing a low overall incidence of fires, namely the Capital Country, Snowy Mountains and Murray regions, the rate per person initially decreased, parallel to the minimum curve, before stabilising at populations exceeding roughly 5,000 people. Postcodes within these regions tended to have lower rates of fires per person than postcodes with populations in excess of 5,000 people. Many postcodes in the North Coast region documented higher than average rates of fires per person.

Considerable variation was evident in the number of fires per person per year in the Sydney region. The highest rates were documented in the Outer Western Sydney, Outer South-Western Sydney, Blacktown, and Fairfield–Liverpool SSDs (Figure 171); that is, in those regions that recorded the highest number of fires overall. This was evident for postcodes with highly diverse populations. This indicates that the lower total fire frequencies observed for some postcodes within southwest Sydney are more likely a reflection of lower total populations than any intrinsic heterogeneity in fire distributions.

There were isolated instances where high rates of fires per person occurred for one or several postcodes within a region that was overall characterised by a lower incidence of fires in total and on a per person basis. Examples include four postcodes within the Bankstown SLA, two postcodes each in the Pittwater and Warringah SLAs, and one postcode each in the Randwick and Strathfield SLAs. The rates for postcodes in the Central Western Sydney SSD appear to have been intermediate between the higher values observed in the southwest and lower value reported elsewhere, consistent with the fact that geographically this area lies between areas of higher and lower rates of fire incidence.

Deliberate fires

Only one postcode in NSW experienced in excess of 500 deliberate fires in two years. This occurred in the North Coast region (Kempsey SLA). Another three postcodes, in the Campbelltown, Bourke and Blacktown–South West SLAs recorded 300 to 500 deliberate fires. Two postcodes documented 200 to 299 and another 21 postcodes had 100 to 199 deliberate fires. The 27 postcodes that had 100 or more deliberate fires in two years accounted for 46 percent of deliberate fires recorded in the state in the two-year period. Of these 27 postcodes, eight were located in the Sydney region. The greatest incidence of postcodes recording in excess of 100 deliberate fires in two years in regional NSW occurred in the Hunter (seven postcodes) and Central Coast (four postcodes) regions. Five of these postcodes were in the Lake Macquarie SLA (Table 5).

Typically, there were between 0.1 and 100 deliberate fires per 10,000 people in NSW postcodes, although higher rates were evident locally in the Bourke, Brewarrina, Lake Macquarie and Kempsey SLAs (Figure 172 to Figure 174). No deliberate fires were recorded in almost 150 postcodes, and hence these postcodes do not appear in Figure 173 and 174. This most significantly affected postcodes containing less than 1,000 people. Many other postcodes occur along a line determined by one deliberate fire in two years. This represents the minimum possible rate greater than zero, for a postcode of any population, and highlights the generally low rates of deliberate fires in these locations.

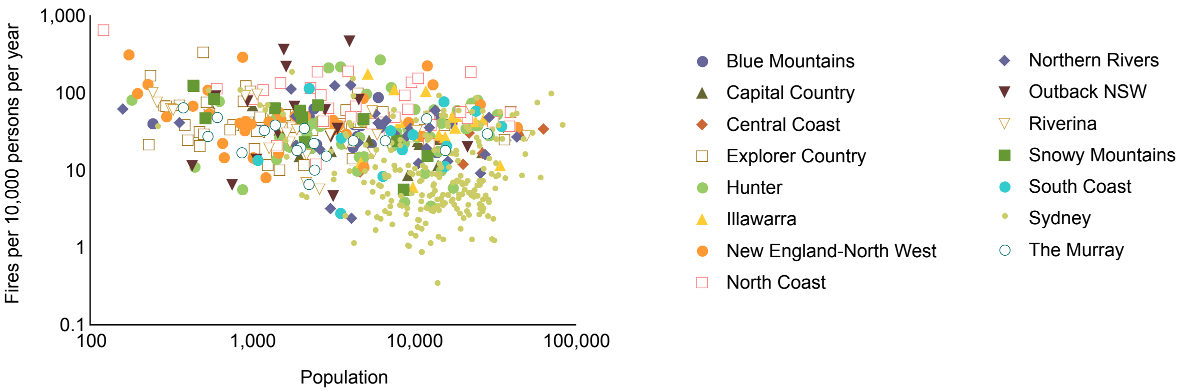
The Outer Western Sydney, Outer South Western Sydney, Liverpool–Fairfield and Blacktown SSDs recorded the highest rates of deliberate fires per person in the Sydney region. Rates in this area were typically in the range of eight to 60 deliberate fires per 10,000 people per year (Figure 174). Most other regions were characterised by rates of one to 10 deliberate fires per person per year. The Central Western Sydney SSD again tended to bridge the range between these two extremes. Occasional postcodes within other areas of the Sydney region also recorded higher rates of deliberate firesetting per person per year. Included within this subset were two postcodes within the Inner Sydney region.

High rates of deliberate fires per person were documented in the Hunter, Central Coast, Illawarra and North Coast (Figure 172); densely populated regions outside of the Sydney region that overall recorded large numbers of fires. The rates of deliberate fires per person in these areas were comparable to those observed in Central and Outer Western Sydney SSDs (Figure 174). The average rates in other regional areas were typically lower (Figure 173), but some caution is needed when interpreting the data owing to the low levels of causal attribution documented for many regional areas.

Overall, there was greater correspondence between the rates of deliberate fires per person observed in metropolitan and regional areas than that observed for total fire numbers per person overall. To some extent this may have been genuine, reflecting the greater likelihood of other fire causes, including burn offs and natural fires in some regional areas. However, lower levels of causal attributions in many regional areas may also have been a contributing factor.

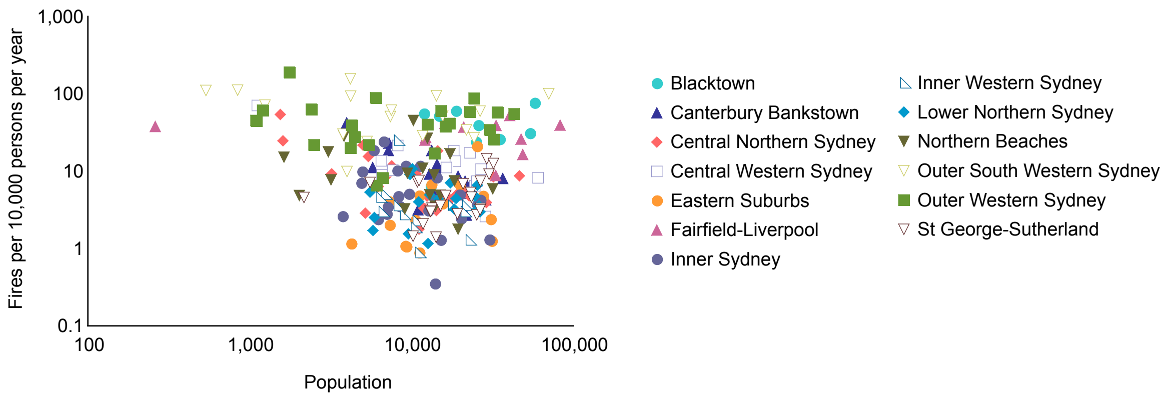
What is clear from this joint analysis is that, overall, the NSWFB and NSWRFS observed high numbers of fires and high numbers of deliberate fires in similar locations. For example, both agencies documented high numbers of fires in the Hunter and Central Coast regions, and North Coast regions. However, it is only on combining the databases that the enormity of the problem is revealed. Although direct comparisons cannot be made, because of the differences in the definitions of regions, it is also evident that both the NSW NPWS and SFNSW attended high numbers of fires in similar areas. This highlights the need for strong cooperation between fire agencies in order to reduce the numbers of fires generally and the number of deliberate fires in particular.

Figure 170: Total fires per 10,000 people per year for individual postcodes within each region (number)



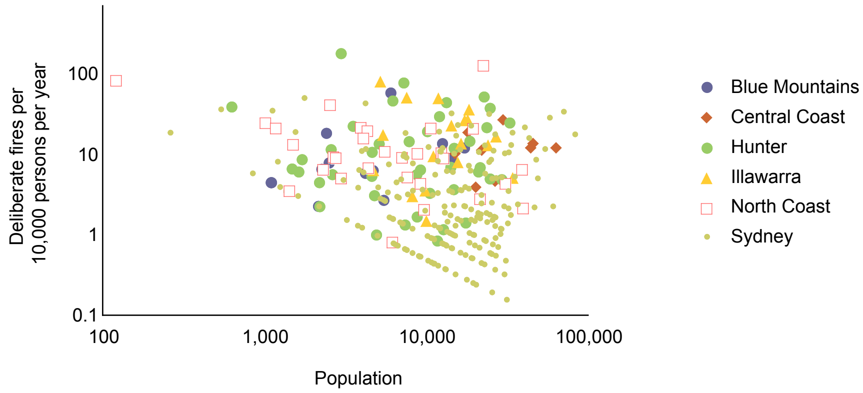
Source: NSWFB 1997–98 to 2001–02 [computer file], NSWRFS 1999–2000 to 2003–04 [computer file]; ABS 2004. Population by post office area, 2001 [computer file]

Figure 171: Fires per 10,000 people per year for individual postcodes within SSDs in the Sydney region (number)



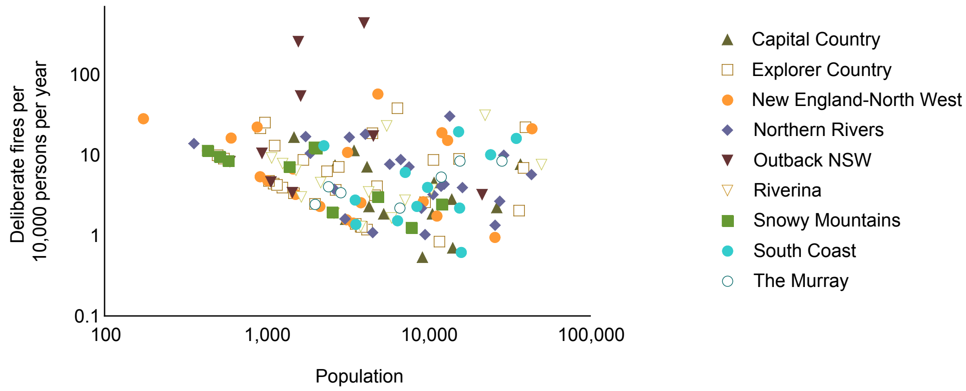
Source: NSWFB 1997–98 to 2001–02 [computer file], NSWRFS 1999–2000 to 2003–04 [computer file]; ABS 2004. Population by post office area, 2001 [computer file]

Figure 172: Deliberate fires per 10,000 people per year for individual postcodes within selected regions (number)



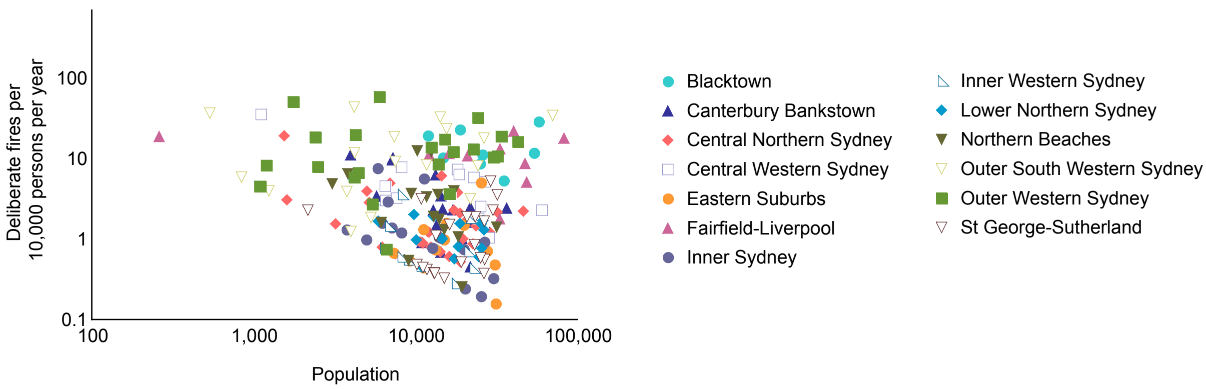
Source: NSWFB 1997–98 to 2001–02 [computer file], NSWRFS 1999–2000 to 2003–04 [computer file]; ABS 2004. Population by post office area, 2001 [computer file]

Figure 173: Deliberate fires per 10,000 people per year for individual postcodes within selected regions (number)



Source: NSWFB 1997–98 to 2001–02 [computer file], NSWRFS 1999–2000 to 2003–04 [computer file]; ABS 2004. Population by post office area, 2001 [computer file]

Figure 174: Deliberate fires per 10,000 people per year for individual postcodes within SSDs in the Sydney region (number)



Source: NSWFB 1997–98 to 2001–02 [computer file], NSWRFS 1999–2000 to 2003–04 [computer file]; ABS 2004. Population by post office area, 2001 [computer file]

Table 5: Number and location (SLA and region) of postcodes where total and deliberate fire numbers exceeded 200 and 100

Region	No. >200 fires	SLA	No. >100 deliberate fires	>100 deliberate fires
Capital Country	1	Queanbeyan		
Central Coast	4	Gosford (2), Wyong (2)	4	Gosford (2), Wyong (2)
Explorer Country	2	Orange, Dubbo	1	Dubbo
Hunter	5	Cessnock (2), Lake Macquarie (2), Singleton	7	Lake Macquarie (5), Cessnock (2)
Illawarra	3	Wollongong (2), Shellharbour	2	Wollongong, Shellharbour
New England North West	4	Moree Plains, Armidale, Tamworth, Inverell	1	Tamworth
North Coast	8	Coffs Harbour (2), Greater Taree, Hastings Pt A, Hastings Pt B, Great Lakes, Port Stephens, Kempsey	1	Kempsey
Northern Rivers	2	Lismore, Grafton		
Outback	1	Bourke	1	Bourke
Riverina	2	Griffith, Wagga Wagga	1	Griffith
South Coast	3	Shoalhaven (C) Pt B (2), Shoalhaven (C) Pt A	1	Shoalhaven (C) Pt B
Sydney	16	Penrith (5), Blacktown (4), Liverpool (3), Campbelltown (3), Fairfield	8	Penrith (3), Liverpool (2), Blacktown (2), Campbelltown

Deliberate fires during adverse fire seasons

This section examines changes in the incidence of deliberate fires during two periods of adverse fire weather in NSW and the extent to which these contributed to total number of fires attended and the total area burned.

Background

Between 1999–2000 and 2003–04 NSW experienced two particularly adverse periods of bushfire activity in which there were large losses of property: October 2001–January 2002 and July 2002–January 2003. Descriptions of these events, derived from NSWRFS (2001, 2003) and Ellis, Kanowski & Whelan (2004), are summarised below.

October 2001 – January 2002: The 2001–02 bushfire season started early when seven bushfire emergencies were declared in the Cessnock, Gosford, Gloucester, Kempsey, Wyong, Greater Taree and Singleton areas between 29 October and 9 November 2001. Another spate of five bushfire emergencies was declared in early December, commencing with the Blue Mountains Rural Fire District. Most of the fires were thought to have been started by lightning strikes from a severe dry thunderstorm. Between 3 and 24 December the Blue Mountains/Lithgow, Hawkesbury, Narromine, Wollondilly/Wingecarribee and Cabonne districts experienced major fires.

By 24 December 2001, as the fires drew closer to Sydney, directly threatening residential property, and because it appeared that many of the fires had been deliberately lit, public and media interest in the fires intensified. By Christmas Day 26 bushfire emergency declarations were made across 48 local government areas. On 16 January 2002, the NSWRFS Commissioner announced that the crisis was over. This was not before 454 fires had burned 744,000 ha and destroyed 109 houses and 6,000 head of livestock in the Greater Sydney region, Hunter, North Coast, and Northern (New England–NW) and Central Tablelands

(Explorer Country). The estimated insurance bill for fire damage between October 2001 and January 2002 was estimated to be $75,000,000 (approximately 3,000 claims); with the estimated cost of operations for NSW fire agencies of approximately $106,000,000. On the positive side an estimated 20,000 properties were saved and there was no loss of life or serious injury to members of the public or emergency personnel.

July 2002 – January 2003: In most states and territories of Australia the 2002–03 bushfire season had the potential to be most severe experienced for 20 and 40 years. In NSW, this potential was manifested with numerous fires occurring over an extended period. Most of the state was into its second consecutive season of drought. This contributed to an abnormally early start to the season, with adverse fire conditions extending over almost five months. Serious fires commenced in the northeast of the state as early as July–September 2002 and were followed by several large and extended firefighting campaigns. These included:

- the alpine regions – Childowla, Brindabella Ranges Complex, Kosciouszko North Complex, Kosciouszko South Complex, Tuross Creek, and Slaughterhouse fire – between December and February
- Shoalhaven – Touga fire – November
- Northern Tablelands and North Coast – September and October
- Hunter and Mid North Coast – October and February
- Blue Mountains – Blackheath Glen, Marked Tree and Airly – October to January
- Bala Range Complex – incorporating Hawkesbury, Cessnock, Singleton and Gosford local government areas – October to December.

Between 1 July 2002 and 28 February 2003 fires burned nearly 1.5 million hectares of land, resulting in the loss of 86 houses (another 28 houses were damaged), as were 33 other major structures, 188 sheds, garages or outbuildings; 102 vehicles, boats or caravans; and about 3,400 head of livestock. Three people lost their lives as a direct consequence of the fires. The cost of insurance claims in NSW during 2002–03 was approximately $40,000,000 with an additional $120,000,000 spent on suppression. This does not include the costs and losses associated with fires that subsequently spread into the ACT, which when combined with fires that had started in the territory, burned 157,000 ha, resulted in the loss of four lives, 580 homes (damage to a further 800 structures), and damage bills of $350,000,000 and suppression costs of $404,000,000.

Although fires in both 2001–02 and 2002–03 resulted in large losses, fundamental differences existed between the two seasons. The dry conditions experienced in 2001–02 were not global-scale climatic perturbations like an El Niño weather pattern. Although natural fires were an important component, the 2001–02 season stands out because of an unprecedented number of fires and area burned by large (greater than 1,000 ha) incendiary and suspicious fires. Based on the available statistics, in 2001–02 deliberate fires accounted for:

- 46 percent (81,000 ha) of the total area burned in SFNSW fires
- 27 percent (90,000 ha) of the total area burned in NSW NPWS fires
- 29 percent (145,000 ha) of the total area burned in NSWRFS fires.

Formulating the total figure burned by deliberate fires is difficult as many large fires may be duplicated across fire agencies' records. Based on the NSWRFS figures, deliberate fires burned a minimum of 145,000 ha.

By contrast, 2002–03 was dominated by an El Niño-like weather pattern, which was exacerbated by drought that had pervaded much of the state during the previous year. Large fires in 2002–03 were principally natural rather than human in origin. This was experienced both early in the season in northern NSW, and during the middle of summer in the south of the state.

Number of fires

Comparisons across agencies are difficult as the datasets cover different years, but overall, there is strong correspondence between yearly fluctuations documented across all four agencies in NSW (Figure 175 and Figure 176); that is, the number of fires broadly decreased and increased during the same years. Singly and collectively, data from these agencies indicate that although deliberate firesetting became a central focus of media and public attention during the December–January fires of 2001–02, the total number of deliberate fires recorded in that year was not particularly remarkable when compared with other years, for example:

- **1997–98**: Most agencies recorded high numbers of deliberate fires during 1997–98, which was another dry season associated with an El Niño event. The NSW NPWS and SFNSW only documented a 20 to 25 percent increase in deliberate fire numbers from 1997–98 to 2001–02. The NSWFB actually recorded 15 percent fewer fires in 2001–02 than in 1997–98, although this data may have been affected by lower levels of causal attribution.
- **2000–01**: The total numbers of deliberate fires in 2001–02 were not substantially different from that recorded in 2000–01. Notably, the SFNSW and NSWFB only recorded a 12 and six percent increase in deliberate fires relative to the previous year. The NSW NPWS recorded nine percent fewer fires in 2001–02 than in 2000–01. A large increase was evident in the number of fires the NSWRFS attended; although it is unclear if this is an apparent error reflecting the graduated introduction of incident reporting within AIRS across the state.
- **2002–03**: The total number of deliberate fires recorded in 2001–02 was not substantially different from that recorded in 2002–03. Notably, the number of deliberate fires the SFNSW attended remained stable, whereas the NSWRFS attended 10 more fires in 2002–03, and the NSW NPWS attended half as many in 2002–03 compared with 2001–02.

These trends are exemplified when fires the NSWFB attended in the Sydney region are examined on a week-by-week basis. Overall, for the NSWFB, there were strong parallels between the timing of deliberate fires (Figure 177) and the timing of fires generally (Figure 178). This reflects the fact that deliberate fires were an important contributor to fire numbers generally but also that the timing of deliberate fires was not fundamentally different to that observed for other fire causes.

The NSWFB attended 344 vegetation fires in the last week of December 2001–02 (Figure 178) of which 77 were identified as deliberately lit (Figure 177). This may seem extraordinary, but NSWFB records indicate that the number of deliberate fires attended in any one week from mid December to mid January were not unprecedented for that time of year; the maximum number of fires attended in any one week in 2001–02 was comparable to that attended in 2000–01, and less than attended during the peak in 1997–98.

The NSWRFS data for the Sydney region during the same interval are more complex. Notably, in contrast to the NSWFB data, the temporal distribution of deliberate fires (Figure 179) do not directly mirror the trend observed for fires generally (Figure 180). Based on the available results, the proportion of deliberate fires appears to increase as the bushfire season progresses, and the critical period in 2001–02 around Christmas–New Year is approached. When viewed in isolation, it appears that arsonists may have preferentially targeted the adverse fire weather during that period. However, considerable caution is needed before taking this view, as this apparent pattern is paralleled by an increase in the proportion of fires to which a cause was assigned; that is, cause was assigned to a far greater proportion of fires during the Christmas–New Year period than to fires in August–November. The reality may be that the number and proportion of deliberate fires does not change substantially throughout the entire fire season, it is just that there is a greater emphasis on identifying the causes of fires during the most adverse fire weather conditions.

As for the NSWFB, the actual numbers of deliberate fires the NSWRFS recorded for weeks 52 to 2 of 2001–02 in the Sydney region were lower than those recorded during the same time in 2002–03, and were substantially lower than was documented for September 2000–01; the season was prematurely curtailed by high spring rainfall. Clearly, it is not only the total fire frequency that is important. The time that those fires occurred is also of significance. Hence, it is necessary to specifically examine changes in the number of fires that occurred within the critical window from weeks 48 to 4.

Mid December (week 48) to late January (week 4) corresponds not only with Christmas school holidays, but represents the window in which NSW most commonly experiences its most adverse fire weather, as reflected in the greater numbers of natural fires during this interval. It is during this window that the most devastating of the 2001–02 and 2002–03 fires occurred. It is valuable, therefore, to examine in detail this time period in detail.

In the Sydney region, the NSWFB attended 463 deliberate vegetation fires from weeks 48 to 4 in 2001–02. Although higher than most previous seasons, this was somewhat lower than in 1997–98 (Figure 181). The number of deliberate fires the NSWRFS recorded for weeks 48 to 4 in 2001–02 was higher in 2001–02 than in 2000–01, but was lower than documented during the same period in 2002–03. Combining the NSWFB and NSWRFS data it appears that the percentage of fires of known cause that resulted from incendiary and suspicious activity has decreased since the late 1990s. This is consistent with the trends observed both on a yearly and a week-by-week basis.

In the Illawarra region, the NSWRFS recorded markedly higher numbers of deliberate fires for weeks 48 to 4 in 2001–02 relative to both 2000–01 and 2002–03 (Figure 182). This was also evident for the Hunter (Figure 183) and Central Coast (Figure 184) regions. This is highly divergent from that observed for the NSWFB data. In all three regions the NSWFB recorded a higher incidence of deliberate fires in 2000–01 relative 2001–02. Notably, the NSWFB attended almost twice as many deliberate fires from weeks 48 to 4 in 2000–01 than in 1999–2000 or 2001–02, in the Hunter and Central Coast regions. The reasons for the differences between NSWFB and NSWRFS data are unclear. One possibility is that there may have been incomplete reporting for the NSWRFS for 2000–01. It is important to take into account the differences in scale. An increase of 20 deliberate fires would have had little impact on NSWFB data, but could have had a profound impact on the NSWRFS; not only in terms of the number of fires, but also the greater potential for larger fires to develop in more open country.

Databases from all four fire agencies recorded a high number of deliberate fires in the North Coast region generally; around 80 percent of NSWFB-attended fires where the cause was known, and 50 percent of NSWRFS-attended fires where the cause was known, resulted from deliberate causes in this region (Figure 185). Although the NSWFB recorded higher numbers of fires in weeks 48 to 4 in 2001–02, compared with 2000–01, they were not substantially different to that documented in 1997–98 to 1999–2000. The NSWRFS observed elevated fire numbers during both 2001–02 and 2002–03 relative to 2000–01 and 2003–04. The proportion of deliberate fire, as a percentage of fires of known cause, remained largely unchanged across seasons for both the NSWRFS and the NSWFB.

In summary, the absolute numbers of deliberate fires observed across 2001–02 and within the critical window from weeks 48 to 4 do not appear to be excessively higher in 2001–02 than in other years. There may have been subtle differences in the extent of deliberate firesetting in some regions; but if those differences were real, they were small and had a greater impact in rural and regional settings.

Area burned

Information about the area burned was available for the NSWRFS, NSW NPWS and the SFNSW. All three agencies' data showed (Figure 186):

- the largest areas were burned in 2002–03, followed by 2001–02 and 2001–01
- natural cause was the principal cause of fires in 2002–03
- both natural and deliberate causes were integral to the total area burned in 2001–02.

For both the SFNSW and NSWRFS, the exceptionally large areas burned by deliberate fires in 2001–02 were a unique occurrence. Notably, for these two agencies the area burned by deliberate fires in 2001–02 was six and 15 times greater than that burned by deliberate causes in 2000–01, respectively. For the SFNSW, the area burned by deliberate fires was 3 times greater in 2001–02 than in 2002–03, despite the severity of the latter fire season. Similarly, the NSW NPWS record smaller areas burned by deliberate fires in 2002–03 as compared with 2001–02, but for that agency the area burned in 2001–02 was actually 25 percent less than that burned in 2000–01.

In order to understand the context of the areas burned by deliberate fires in 2001–02, it is necessary to examine the timing and cause of large fires overall. Previously conducted data analysis highlighted the existence of two principal peaks in fire activity in the NSW fire season, which for the purposes of the following analysis will be referred to as:

- early season fires (typically August to October–November; weeks 31 to 47)
- peak season fires (December–January; weeks 48 to 5); termed peak season because this period coincides with the dominant timing for natural fire events in NSW, and the period during which the most destructive fires have occurred.

Three principal factors contribute to early season fires:

- The majority of fires in northern NSW (Northern Rivers and North Coast) regions occurred during late winter and early spring.
- The majority of burn offs (legal and illegal), as reflected in the NSW NPWS and SFNSW data, took place during spring.
- Contributions from incendiary and deliberate fires of unknown intention.

Late season fires appear to reflect two dominant factors, namely:

- Peak numbers of natural fire in central and southern NSW.
- Increased incendiary lighting, particularly in selected urban areas, coincident with a holiday period.

The NSW NPWS observed a substantial increase in both the areas burned by, and the principal causes of, early and peak season fires from 2000–01 to 2003–04 as described below.

- In 2000–01, not a particularly adverse bushfire season, the overwhelming majority of the total area was burned by early season fires (Figure 187). Of the 460,000 ha burned in 2000–01 between weeks 31 and 5, 97 percent was burned during the early season (prior to week 48), and of that almost two-thirds was burned by incendiary or suspicious fires. Approximately 15,000 ha burned in fires from week 48 to week 5. Of this, 48 percent resulted from incendiary and suspicious fires.

- Early season fires also occurred in 2001–02, with 93,000 ha being burned in weeks 31 to 48 (Figure 188). Of this, 56 percent resulted from incendiary and suspicious causes. However, this area was dwarfed by the 682,000 ha that was burned from weeks 48 to 5. Approximately 134,000 ha of that were burned in incendiary and suspicious fires. Nevertheless, this comprised only one-fifth of the total area burned by fires during the same period. The majority resulted from natural fires and reignition. Approximately 30 percent of the area burned in December–January fires were from fires of unknown cause. Two factors that differentiated the 2001–02 season are the large area burned and the significant part that deliberate human actions likely played in peak season fires.
- 2002–03 was markedly different again. Natural fires predominated throughout both the early and peak season periods, with similar total areas being burned in the two intervals (Figure 189). Accidental fires principally occurred before week 41 (late October). Incendiary and suspicious fires burned approximately 148,000 ha during 2002–03, but 98.5 percent of those occurred before week 48 in early December. Deliberate fires appeared to largely post-date accidental fires within the early season. In contrast to the previous season, very little was burned by deliberate fires in December and January.
- 2003–04 was a mild season with the majority of land being burned in early season fires (Figure 190). However, in contrast to previous years, and 2000–01 in particular, the overwhelming majority of fires resulted from accidental rather than deliberate causes.

The implication from the NSW NPWS data is that large areas are burned in early season fires every year, but during particularly adverse seasons far greater areas are burned in peak season fires; in 2001–02 peak season fires principally resulted from natural and deliberate causes, whereas for 2002–03 natural causes were the overwhelming contributor. Superimposed on this trend have been fundamental changes in the principal causes of early season fires; from deliberate causes in 2000–01 and 2001–02, to natural causes in 2002–03, to principally accidental causes in 2003–04. Despite this change in cause, deliberate fires have contributed to greater areas burned during the early season in all years except 2001–02.

The trends observed for the SFNSW and NSWRFS are somewhat different to those observed in the NSW NPWS data. For SFNSW the overwhelming majority of the area was burned during the early season; 2001–02 was the only exception (Figure 191). Like the trends observed for NSW NPWS, greater areas were burned in early season fires in all years except 2001–02.

For the NSWRFS, the greatest total area was burned in early season fires in the mildest years, but during peak season in adverse years (Figure 191). However, like the NSW NPWS and SFNSW, greater areas were burned by deliberate fires in the early season, compared with the peak season in all years except 2001–02 (Figure 192).

Early season fires: Illegal burn offs played an integral role in the large areas burned by deliberate fires during the early season. The NSW NPWS attended the greatest number of illegal burns during the early season of 2000–01 in the Hunter and Mid North Coast, New England Tablelands, and to a lesser extent Northern Rivers and Sydney and surrounds (Figure 193); that is, in regions that generally experienced the greatest number of burn offs. Overall these illegal burns, like burn offs generally, tended to be moderately large (Figures 194). However, for the NSW NPWS the proportion of total area burned in illegal, relative to legal burns, has decreased markedly since 2000–01 (Figure 195), with much of this being due to changes in early season fires.

Illegal burns are also likely to be an important contributor to the number and areas burned by SFNSW-attended fires during the early season, if the general distribution for burn offs is a representative guide. While no definitive information exists, it is evident that most rural burns the SFNSW attended occurred within the period between weeks 31 and 48 (Figure 196). The SFNSW attends the greatest numbers of rural burns in the Northern Rivers (principally Casino), North Coast (Coffs Harbour, Wauchope and Taree) and Hunter (principally Newcastle) regions. It is not unrealistic to assume that most illegal burns will also occur between weeks 31 and 48, in these regions. Rural burns burned large areas in both 2000–01 and 2002–03; comparatively smaller areas were burned as a result of this cause in 2001–02 (Figure 197).

No information is available from the NSWRFS data specifically regarding burn offs, as the form of heat of ignition variable was not supplied. However, fires resulting from inadequate control of an open flame peak between weeks 27 and 42, consistent with the timing documents for burn offs the NSW NPWS and SFNSW attended.

In summary, burning off is a practice that occurs every year, and although variable, a proportion of burn offs every year are likely to be illegal. Given that burn offs are on average larger than deliberate fires of other causes, it is not implausible that deliberate fires may contribute to comparatively large areas burned during the early season in most seasons.

Peak season fires: As noted above, 2001–02 is distinguished by the exceptionally large areas burned by deliberate fires during the peak season. Before proceeding, it is reiterated that the total areas burned are governed by large fire events, and that the overall figures can be shaped by a single large fire event. For example, the largest deliberate fire in 2001–02 burned just over 80,000 ha, accounting for almost 60 percent of the total area burned by deliberate fires. Moreover, it needs to be recognised that this fire was labelled suspicious, and was not definitely identified as having resulted from incendiary causes. On other hand, there were many large (greater than 5,000 ha) incendiary and suspicious fires during the 2001–02 peak season.

There are potentially several different factors that contribute to high numbers of deliberate fires during the peak season of 2001–02; illegal burn offs, systematic/background firesetting, and deliberate firesetting targeting adverse weather conditions. There is no possible way to distinguish between these factors, but some discussion is warranted.

It is evident, from the discussions above, that high numbers of deliberate fires occurred during peak season every year, with the greatest number occurring in those regions characterised by high population densities. Most fires occurred in or near urban areas. These fires were small, and the continuance or even increase in such practices during adverse periods of fire danger was accompanied by increased danger of escape. Therefore, it is possible that a small proportion of fires lit within context of ‘normal’ background firesetting may have escaped and developed into large-scale bushfires. It is however, evident that a small number of increases occurred in the numbers of deliberate fires attended by the NSWRFS in specific areas. This may imply an increase in arsonists targeting vulnerable sites, however, this must be considered in light of the commonly large variations in unknown attribution, and the likelihood that fires during this critical time would have been more likely to have been classified as deliberate, relative to other years in which the weather conditions were less adverse. The numbers of fires arising from targeted arson are probably small, but then again comparatively few such fires are required to contribute to high losses. Although no definitive links can be drawn, it is emphasised that most large deliberate fires occurred in those regions that generally record high numbers and/or proportion of deliberate fires; namely the Sydney, Hunter, Illawarra, North Coast, Central Coast regions.

It is also difficult to accurately assess the extent of illegal burn offs during the peak season. While a small number of fires have been labelled as illegal burn offs, it is also likely that many such fires would have simply been labelled incendiary, owing to the adversity of the conditions. Indicators of illegal burn offs during adverse peak periods are discussed below.

Of the 11 documented cases of illegal burning off the NSW NPWS attended between weeks 48 and 4 in the years 1995–96 to 2003–04, three were in the Hunter and Mid North Coast region, four were in the Northern Rivers region, three were in the New England Tablelands, and one was in the Sydney and surrounds region. Three such fires occurred during 2001–02, one each in the Sydney and surrounds, Northern Rivers and New England Tablelands regions (Figure 193), which with the exception of the Hunter is largely consistent with the distribution described above. The three fires in 2001–02 fires burned 500, 2,000 and 3,872 ha respectively, falling within the range observed for burn off generally between weeks 31 and 5 of 2001–02 (Figure 194).

All SFNSW districts, except Urunga, Forbes, Eden and Batemans Bay, experienced at least one rural burn in weeks 48 to 4 in the years 1997–98 to 2002–03. Within the same timeframe 20 burns occurred in the Casino region, five in the Newcastle region, three in the Wauchope region and two each in the Taree, Coffs Harbour and Bathurst regions. Given this, it is perhaps not surprising then that four burn offs were observed in the Casino area in weeks 49 to 52 of 2001–02 (Figure 195). These burn offs burned between 450 and 2,000 ha each, being comparable in size to other SFNSW burn off attended between week 31 and 5 (Figure 196). Another fire occurred in the Bathurst region during week 48 of that year but only burned 0.5 ha. An assessment cannot be made based on the available NSWRFS data.

The implication from this analysis is that past temporal trends, whether in relation to deliberate firesetting, or illegal burns, provide the strongest predictor for areas that are likely to experience deliberate fires in the future. Having said this, some notable trends are evident between the 2001–02 and 2002–03 seasons.

Differences between 2001–02 and 2002–03

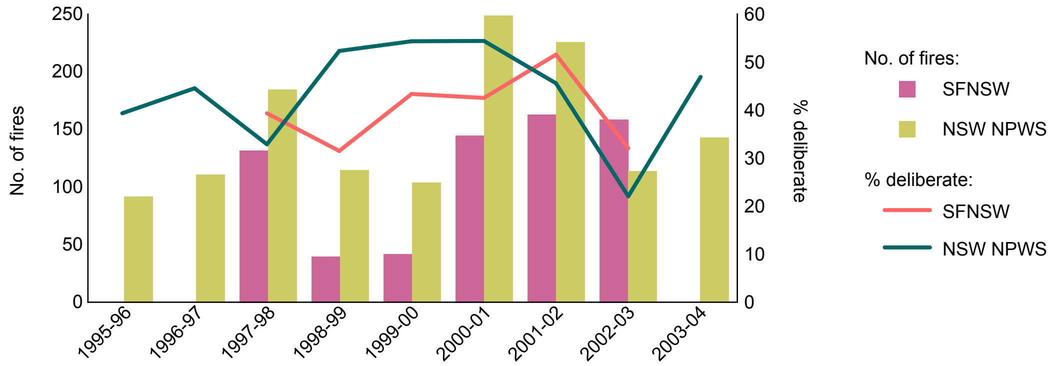
One factor that appears consistent across the NSW NPWS, NSWRFS and SFNSW databases is that fewer large deliberate fires have occurred during the peak season since 2001–02. This is observed both at state and region levels, and is clearly demonstrated in the SFNSW data by the fact that:

- although there were many moderate to large fires in the Newcastle region during December–January 2001–02 (Figure 198), only one such fire occurred in 2002–03 (Figure 199) and it burned less than 50 ha
- no fire in the Wauchope region during the peak season of 2002–03 burned in excess of 10 ha (Figure 198) whereas in the previous season more than 10,000 ha were burned during the same timeframe (Figure 199).

Similar changes are evident within the NSW NPWS and the NSWRFS data. It is unlikely that this simply reflects lower fire danger given the severity of the 2002–03 season. This research cannot evaluate whether this reflects changes in policy, policing, changes in personal behaviour in light of the 2001–02 devastation, or simply that in 2002–03 these areas were characterised by low fuel loads following the 2001–02 fires.

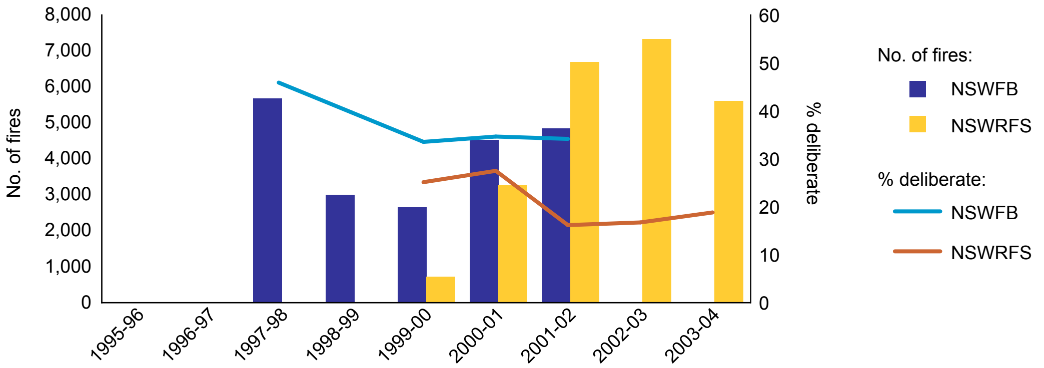
However, there are some aspects that may not have changed as a result of the 2001–02 fires. The numbers of deliberate vegetation fires that fire agencies attended during peak seasons remained high. A small number of illegal burns continued to occur during the peak season of 2002–03, despite the severity of the season. The SFNSW observed large numbers of small fires in the Taree region during the peak season of 2002–03 (Figure 198), when no such population existed in the previous year (Figure 197). A small number of fires continued to occur in the Bathurst region coincident with adverse weather conditions elsewhere in the state in both 2001–02 and 2002–03.

Figure 175: Deliberate fires attended by NSW land management agencies, yearly



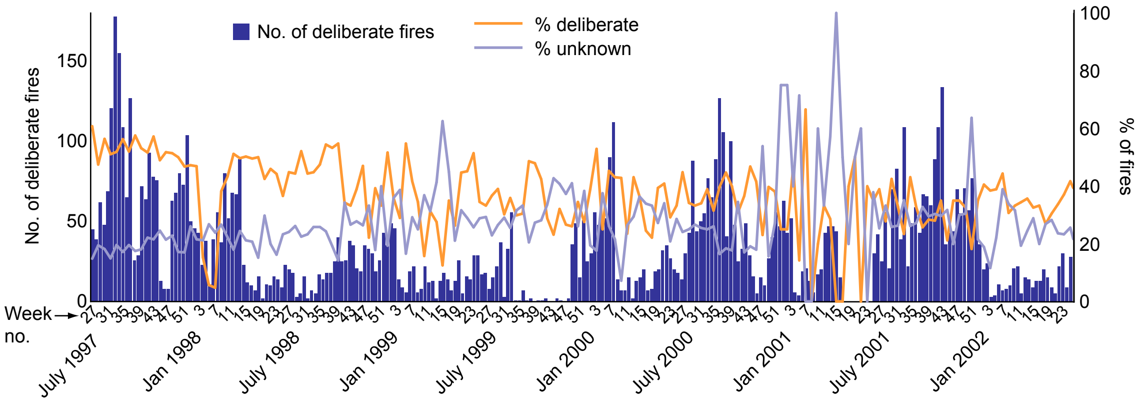
Source: SFNSW 1997–98 to 2002–03, NSW NPWS 1995–96 [computer file]

Figure 176: Deliberate fires attended by rural and urban NSW fire agencies, yearly



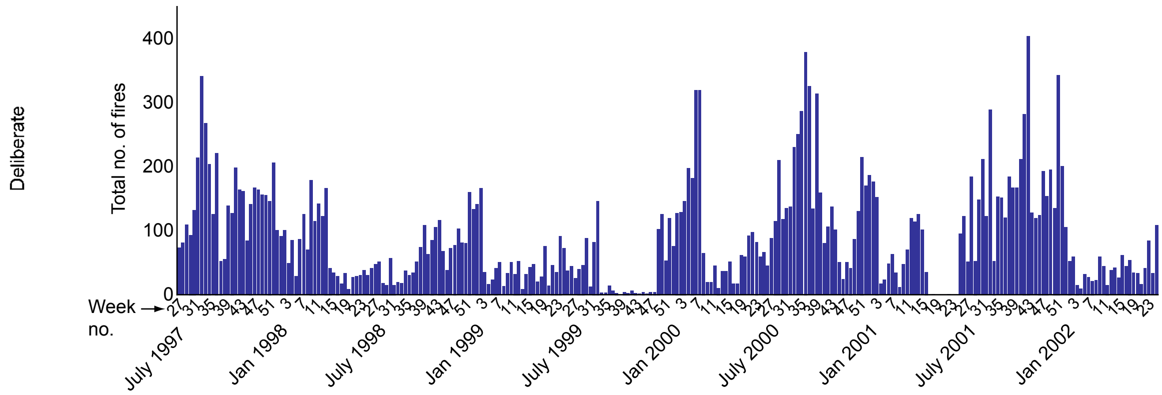
Source: NSWFB 1997–98 to 2001–02, NSWRFS 1999–2000 to 2003–04 [computer file]

Figure 177: Number of deliberate fires, and percentage of fires of deliberate and unknown causes, by week, attended by the NSWFB in the Sydney region



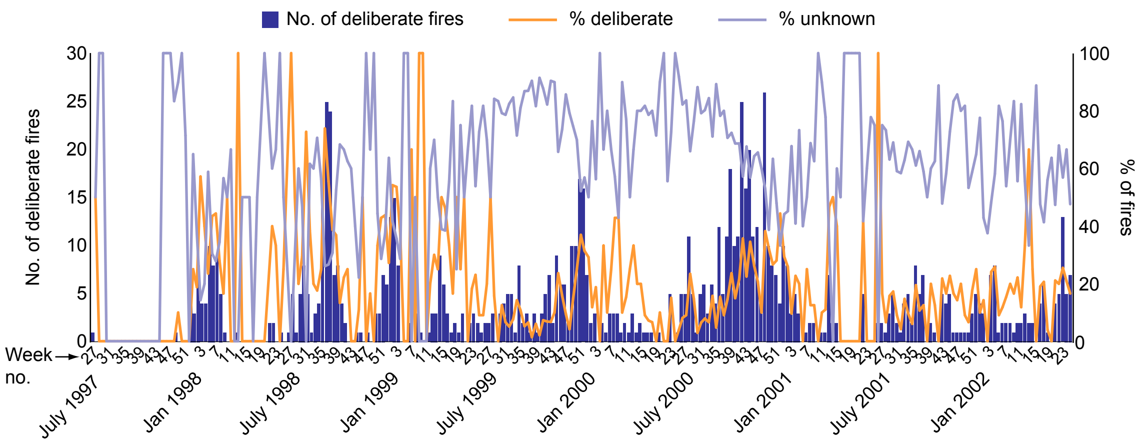
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 178: Fires, by week of the year, for the Sydney region, NSWFB only (number)



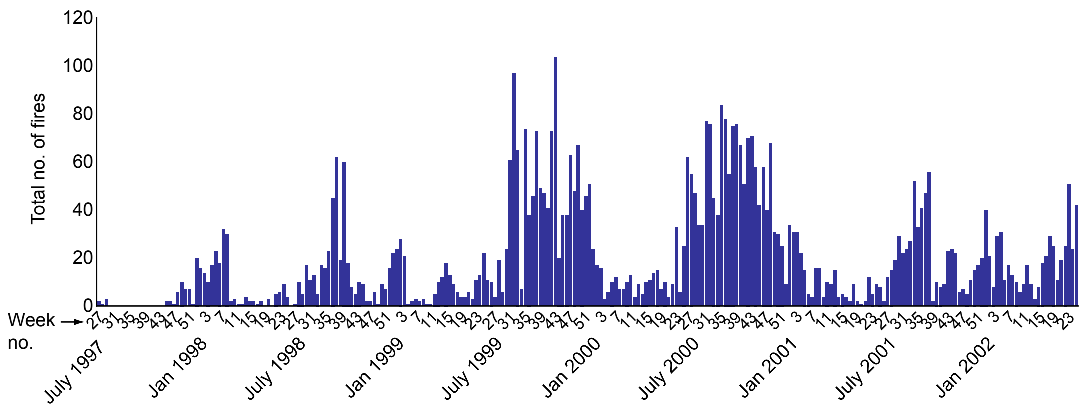
Source: NSWFB 1997–98 to 2001–02 [computer file]

Figure 179: Number of deliberate fires, and percentage of fires of deliberate and unknown causes, by week, attended by the NSWRFS in the Sydney region



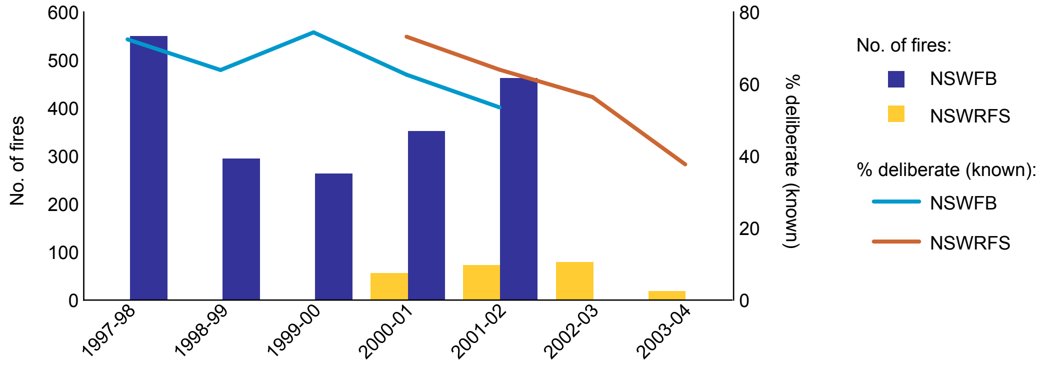
Source: NSWRFS 1999–2000 to 2003–04 [computer file]

Figure 180: Fires, by week of the year, for the Sydney region, NSWRFS only (number)



Source: NSWRFS 1999–2000 to 2003–04 [computer file]

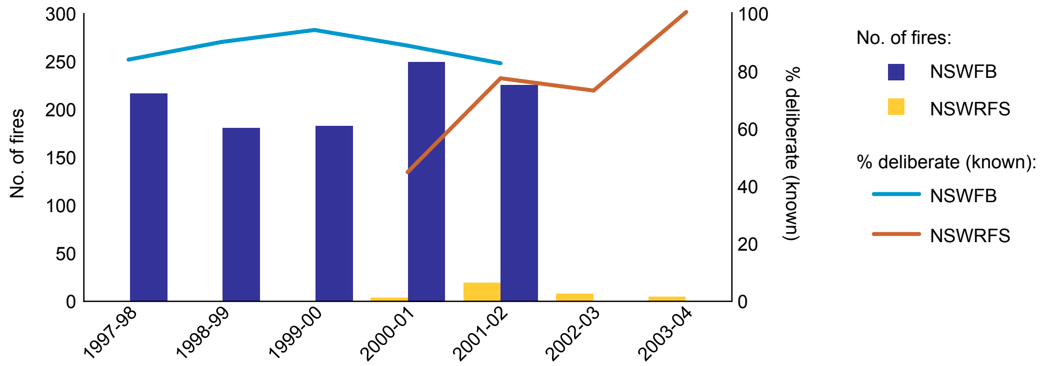
Figure 181: Number and percentage of deliberate (known)[a] fires in the Sydney region each year, NSWRFS and NSWFB



a: percentage of deliberate (known) refers the percentage of all fires of 'known' cause that were attributed to deliberate causes

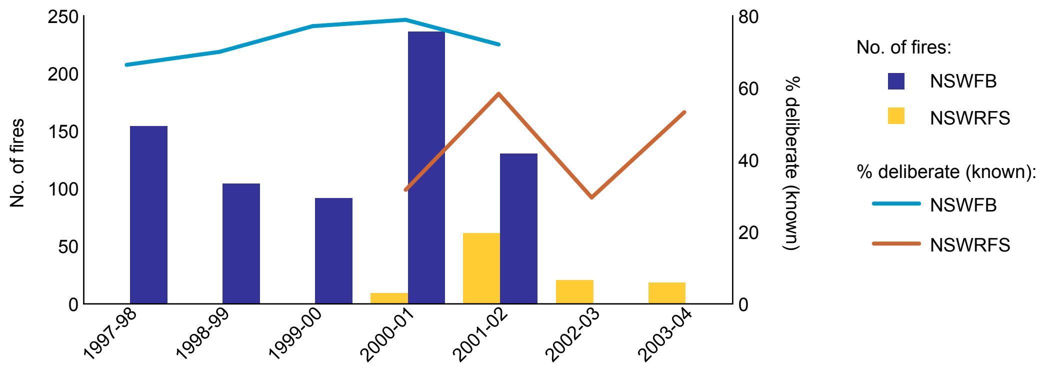
Source: NSWFB 1997–98 to 2001–02, NSWRFS 1999–2000 to 2003–04 [computer file]

Figure 182: Deliberate fires in the Illawarra region, NSWRFS and NSWFB



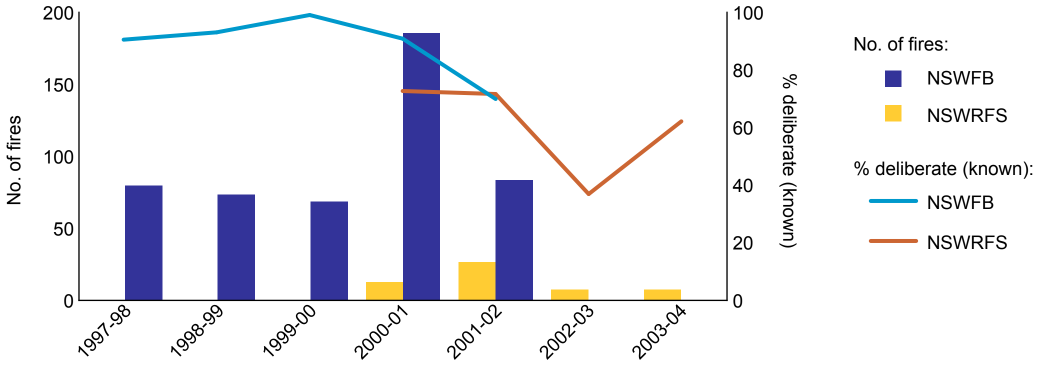
Source: NSWFB 1997–98 to 2001–02, NSWRFS 1999–2000 to 2003–04 [computer file]

Figure 183: Deliberate fires in the Hunter region, NSWRFS and NSWFB



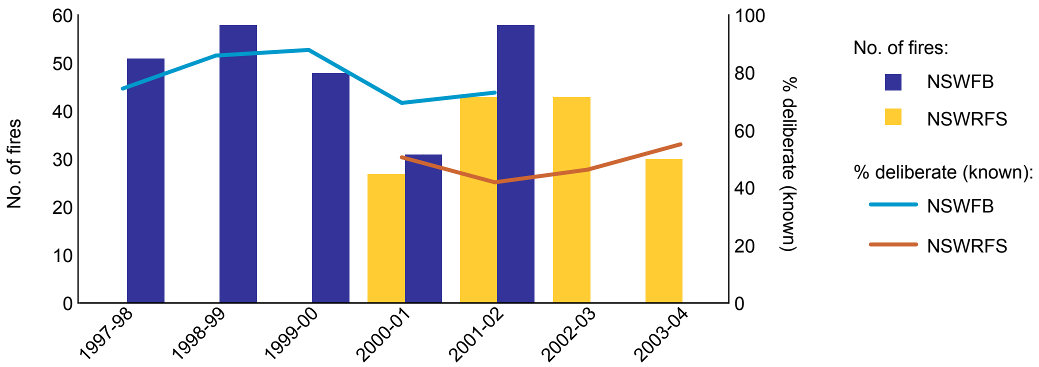
Source: NSWFB 1997–98 to 2001–02, NSWRFS 1999–2000 to 2003–04 [computer file]

Figure 184: Deliberate fires in the Central Coast region, NSWRFS and NSWFB



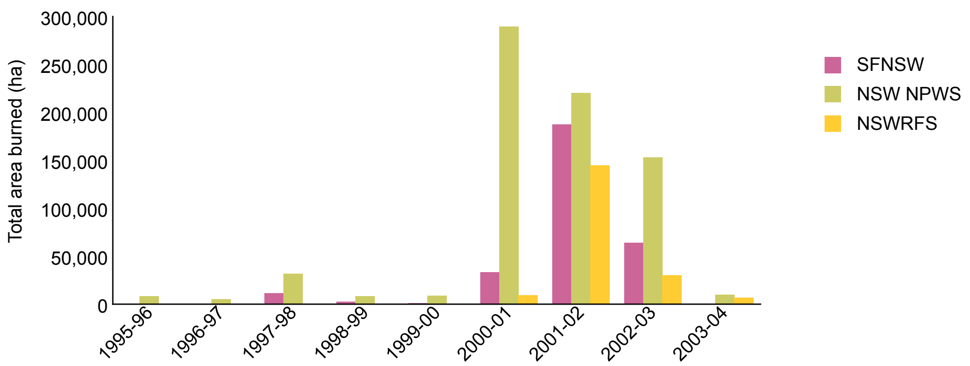
Source: NSWFB 1997–98 to 2001–02, NSWRFS 1999–2000 to 2003–04 [computer file]

Figure 185: Deliberate fires in the North Coast region, NSWRFS and NSWFB



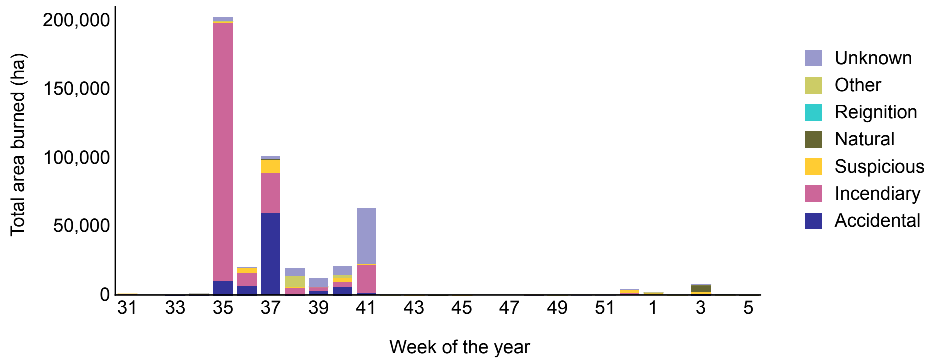
Source: NSWFB 1997–98 to 2001–02, NSWRFS 1999–2000 to 2003–04 [computer file]

Figure 186: Total area burned, annually, in deliberate fires, NSWRFS, SFNSW and NSW NPWS (number)



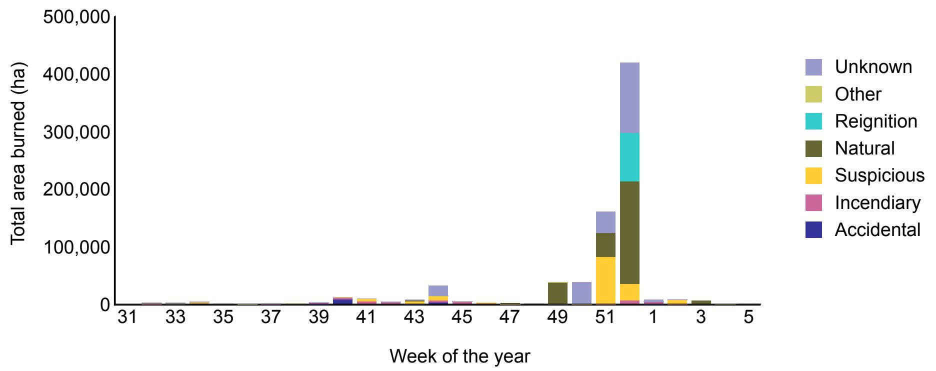
Source: NSWRFS 1999–2000 to 2003–04, SFNSW 1997–98 to 2002–03, NSW NPWS 1995–96 [computer file]

Figure 187: Total area burned, by cause, each week, NSW NPWS, 2000–01 (number)



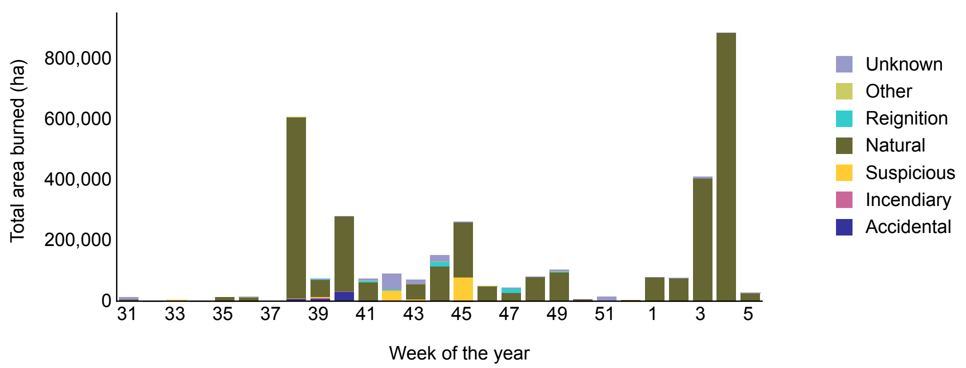
Source: NSW NPWS 1995–96 [computer file]

Figure 188: Total area burned, by cause, each week, NSW NPWS, 2001–02 (number)



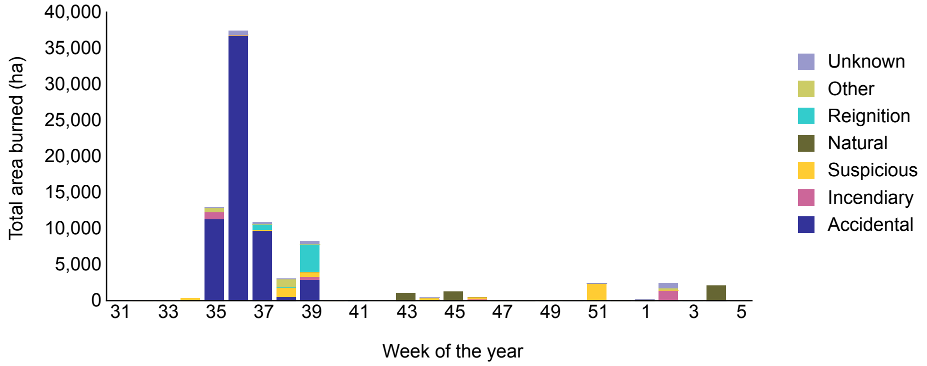
Source: NSW NPWS 1995–96 [computer file]

Figure 189: Total area burned, by cause, each week, NSW NPWS, 2002–03 (number)



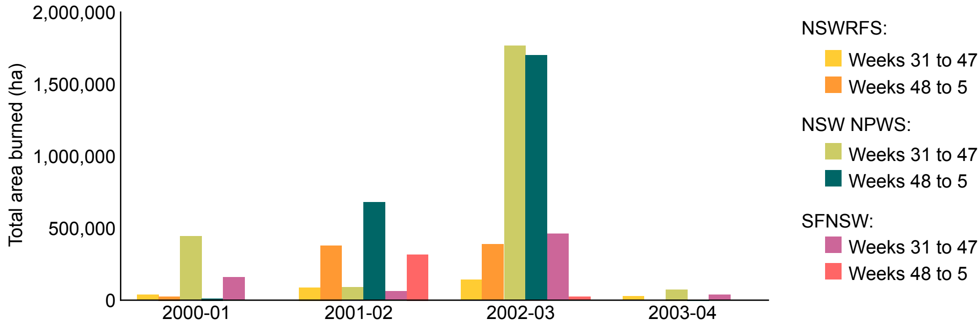
Source: NSW NPWS 1995–96 [computer file]

Figure 190: Total area burned, by cause, each week, NSW NPWS, 2003–04 (number)



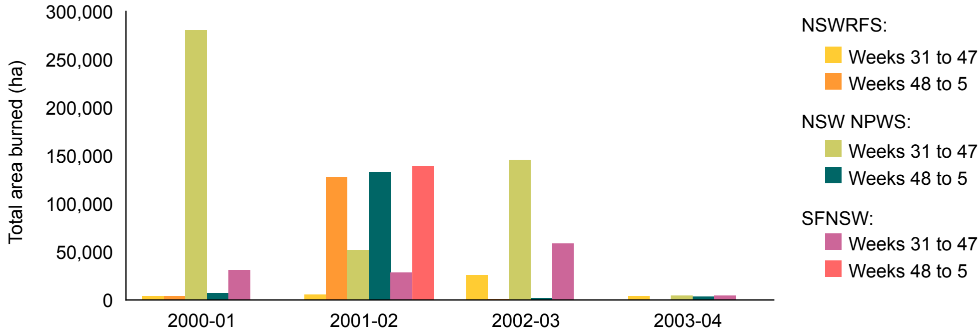
Source: NSW NPWS 1995–96 [computer file]

Figure 191: Total area burned in all early (weeks 31 to 47) and peak season (weeks 48 to 5) fires, individual NSW fire agencies (number)



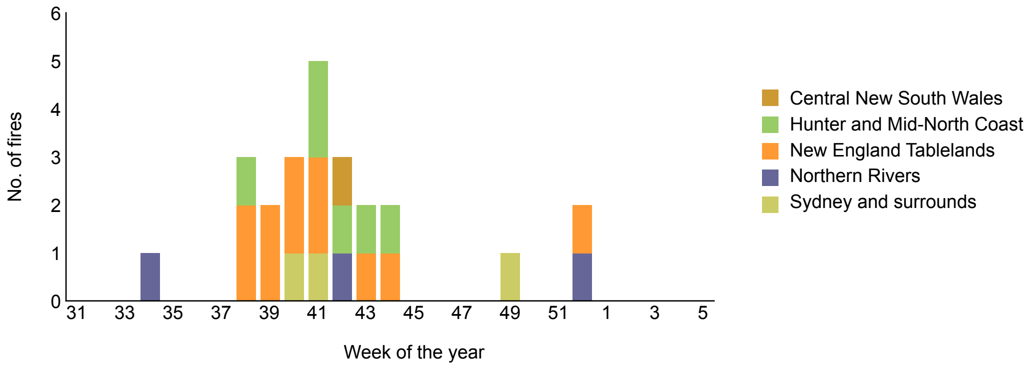
Source: NSWRFS 1999–2000 to 2003–04, SFNSW 1997–98 to 2002–03, NSW NPWS 1995–96 [computer file]

Figure 192: Total area burned in deliberate early (weeks 31 to 47) and peak season (weeks 48 to 5) fires, individual NSW fire agencies (number)



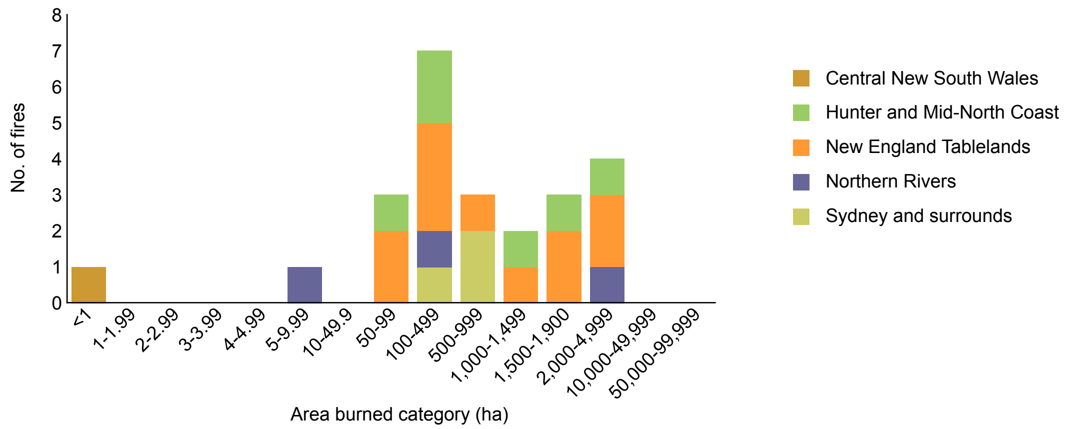
Source: NSWRFS 1999–2000 to 2003–04, SFNSW 1997–98 to 2002–03, NSW NPWS 1995–96 [computer file]

Figure 193: Illegal burn offs, by week of the year, by region, NSW NPWS 2001–02 (number)



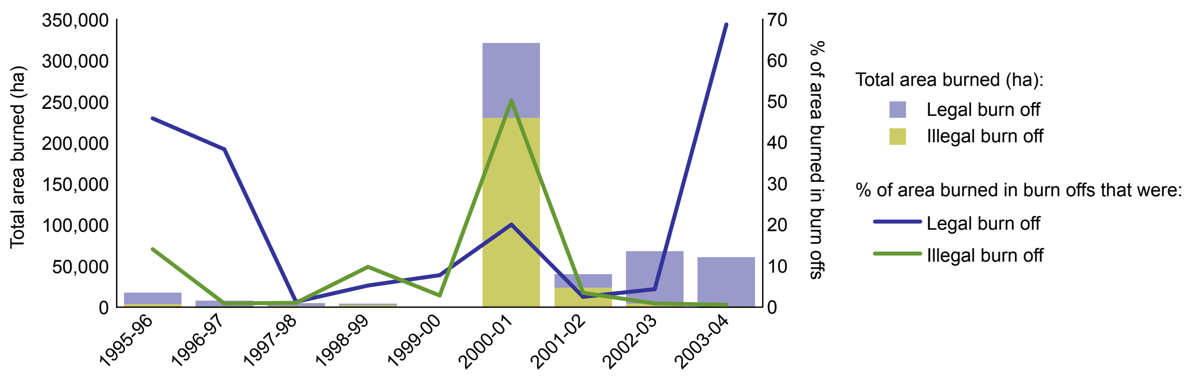
Source: NSW NPWS 1995–96 [computer file]

Figure 194: Illegal burn offs between weeks 31 and 5, by area burned (ha), by region, NSW NPWS 2001–02 (number)



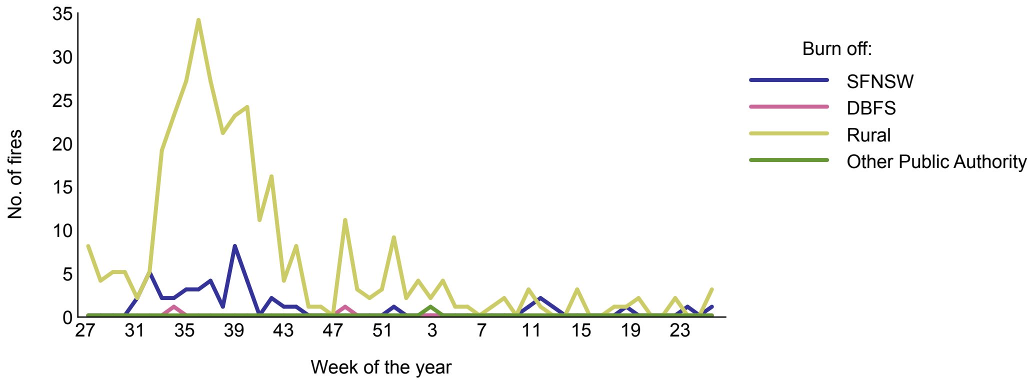
Source: NSW NPWS 1995–96 [computer file]

Figure 195: Area burned annually by legal and illegal burns, NSW NPWS



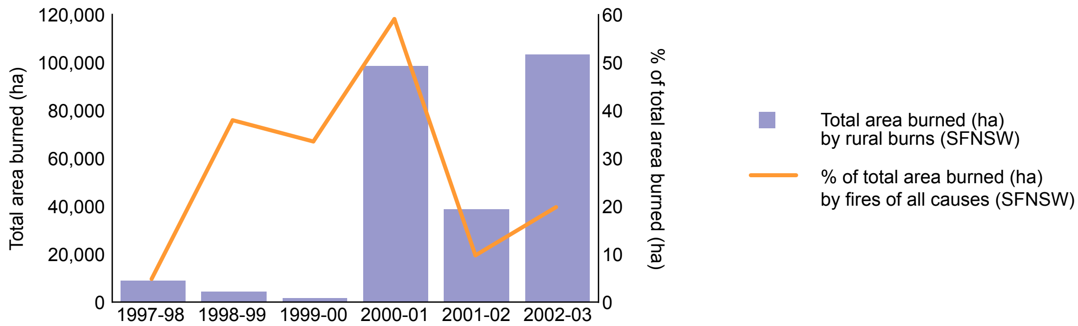
Source: NSW NPWS 1995–96 [computer file]

Figure 196: Rural and other burns, by week of the year for all SFNSW fires (number)



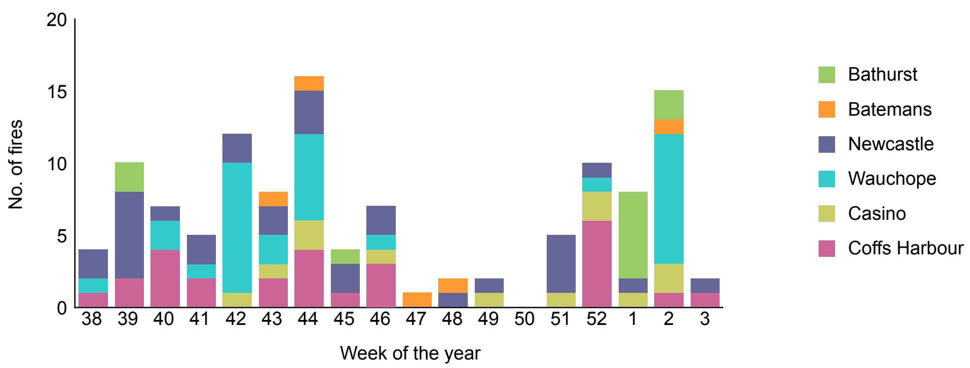
Source: SFNSW 1997–98 to 2002–03 [computer file]

Figure 197: Area burned annually by rural burns, SFNSW



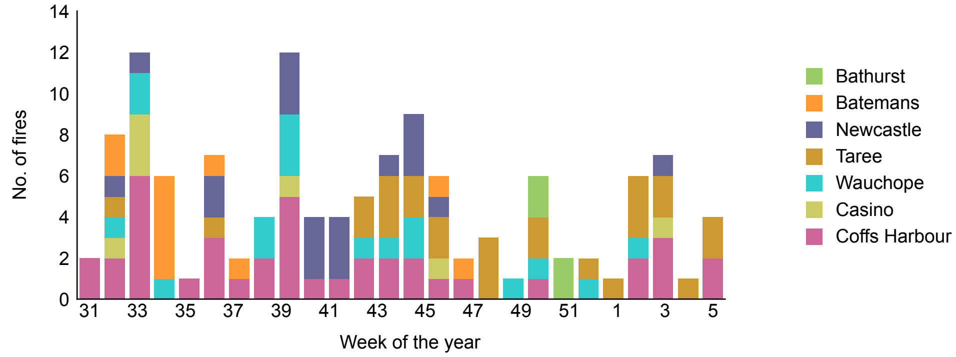
Source: SFNSW 2002–03 [computer file]

Figure 198: Deliberate fires, by week of the year, by region, SFNSW 2001–02 (number)



Source: SFNSW 2001–02 [computer file]

Figure 199: Deliberate fires, by week of the year, by region, SFNSW 2002–03 (number)



Source: SFNSW 2002–03 [computer file]

Summary

Number of fires: Information about the number of fires all NSW fire agencies attended during the observation period are summarised below:

- Fire services attended approximately 16,500 vegetation fires across NSW every year (based on data provided). This is slightly lower than that reported to the Australian Productivity Commission, where the number of landscape (vegetation) fires varied between 17,000 and 22,000 for the years 2000–01 to 2004–05 (APC 2006).
- Differences in the years analysed, incomplete data during implementation of the AIRS database, and industrial actions are several factors that may have contributed to differences between the average numbers documented herein and that reported to the Australian Productivity Commission (APC 2006).
- According to Australian Productivity Commission data, between 39 and 46 percent of all fires attended in NSW every year were landscape (vegetation) fires.
- The NSWFB (urban) attends approximately two-thirds of all vegetation fires in NSW, the NSWRFS 29 percent, and the NSW NPWS and SFNSW approximately two percent each. The figures for NPWS and SFNSW represent a maximum, as fires in these jurisdictions are commonly duplicated across agencies.

The type and location of incidents attended varied markedly between agencies. Salient points can be summarised as:

- **NSWRFS**: No specific information was available about the types of incidents attended but it is noted that 70 percent of all fires attended occurred on private land, 21 percent on local, federal and other public lands, and four percent each in state and national parks. Of those incidents attended, approximately 88 percent were grassfires, 1.9 percent in heathland and 1.7. in native eucalypt forest. The proportion of fires that constituted a bushfire or had the potential to develop into a bushfire is unknown; eight percent is a minimum but actual figures may be considerably higher.
- **NSWFB**: attended a large number of small fires. The number or proportion of fires that either constituted a bushfire or had the potential to develop into a bushfire under adverse conditions is unknown; 60 percent of fires were grass fires, 17 percent were scrub, bush and grass mixtures, and 18 percent were small vegetation fires. These three incident types constituted the bulk of vegetation fires in all regions. The cause of fires was remarkably similar across different incident types although it is noted that the proportion of deliberate fires was lower for grain and crop fires and higher for orchard, vineyard and nursery fires.

- **NSW NPWS**: fires most probably either constituted a bushfire or had the potential to develop into a bushfire under adverse conditions and/or in the absence of timely suppression activities. Sixty-three percent of fires occurred on NSW NPWS tenure, 24 percent on private property/lease, and five percent in state forests. Eighty-seven percent of all fires originating on NSW NPWS lands were contained on those lands, almost half the fires originating outside NSW NPWS tenure, subsequently spread onto NSW NPWS's lands.
- **SFNSW**: fires most probably either constituted a bushfire or had the potential to develop into a bushfire under adverse conditions and/or in the absence of timely suppression activities. Sixty-seven percent were in state forests, 26 percent on private property/leasehold and four percent in national parks.

Cause of fires in NSW is summarised in Table 6 and in the following text.

Deliberate fires comprised 19 to 41 percent of all fires individual agencies attended. The large range principally reflects differences in the levels of causal attribution, which are variable across the state, but lowest overall for the NSWRFS. Deliberate fires comprised 38 to 56 percent of known causes of vegetation fires for individual agencies. On average (agency weighted basis) deliberate fires accounted for at least 32 percent of all fires attended, representing 51 percent of known causes of vegetation fires in NSW (Table 6).

Natural fires accounted for one-fifth to one-quarter of all fires land management agencies attended, approximately one-tenth of fires the NSWRFS attended, and less than one percent of all fires urban brigades attended (Table 6).

Non-deliberate child fires accounted for 0.4 to 16 percent of all fires (Table 6), being greatest for urban brigades; in rural areas 6 to 12 years were most implicated (59% of 6 to 12 year olds, 33% of 13 to 16 year olds) whereas in urban areas a greater proportion of identified children were older (20% of 6 to 12 year olds, 37% of 13 to 16 year olds, 42% of unknown age). NSWFB indicates non-deliberate child fires accounted for higher proportions of all fires over time, and that most fires were started with an open flame (principally matches and, to a lesser extent, lighters).

Smoking-related fires comprised between 0.1 and six percent of all fires individual agencies attended, being considerably greater in urban areas compared with regional areas (Table 6).

In addition:

- **NSWRFS**: principal causes of accidental fires were inadequate control of an open flame, reignition, vehicle fires, high wind, and other ignition factors.
- **NSW NPWS**: 12 percent of fires were burn offs and almost one-third of burn offs were illegal; the proportion of illegal burns attended has decreased since 2000–01, when almost half were illegal. Motor vehicles were implicated in five percent of fires; of these one-third (1.5% overall) involved arson.
- **SFNSW**: 18 percent of fires were rural burns; the proportion of illegal burns is unknown.

Table 6: Fire cause

Agency	% Incendiary	% Suspicious	% Deliberate (known)	% Natural	% Non-deliberate child fires	% Smoking-related fires	% Rural burns
NSWRFS	2.6	15.9	19 (38)	9	0.4	0.7	unknown
NSWFB	14.6	22.6	37 (56)	1	16	6	
NSW NPWS	21.2	19.7	41 (48)	25		0.1	12
SFNSW	38.5		39 (40)	20		1.3	18

Location: Vegetation fires are heterogeneously distributed across the state. Thirty-six percent of all fires the NSWRFS and NSWFB attended occurred in the Sydney region, with large numbers of fires also occurring in the Hunter, North Coast (11%), New England–North West, Illawarra, Northern Rivers and Explorer Country regions:

- Overall, the greatest numbers of fires occurred in regions of greatest population density; hence most fires occurred along the eastern seaboard, commonly within close proximity to the metropolitan area.
- Fires were heterogeneously distributed within individual regions; in the Sydney region higher numbers of fires occurred in the Outer South Western, Fairfield–Liverpool, Blacktown and Canterbury–Bankstown SSDs; comparatively fewer fires occurred in the Inner Sydney, Eastern Suburbs, Lower Northern and Inner Western SSDs.
- Integrating causal data for the NSWRFS and NSWFB was complicated by the substantially lower rates of causal attributions in the NSWRFS data.
- Deliberate causes accounted for a high proportion of all fires in densely populated urban areas that experienced a high number of fires. Hence, high proportions of deliberate fires are observed in the Sydney, Illawarra, Hunter, Blue Mountains, Central Coast, North Coast and South Coast region. Similarly higher rates were evident in southwest Sydney when compared to other locations within the Sydney region.
- Individual locations with high rates of deliberate firesetting commonly accounted for a disproportionate number of all fires within a region, and a disproportionate number of deliberate fires within a given region or state. For example, 10 postcodes accounted for half of all deliberate fires the NSWFB attended in the Sydney region, and one-fifth of all deliberate fires it attended across the state.
- Regions where there were high rates of deliberate firesetting in urban areas also commonly experienced high rates of deliberate firesetting in rural, forestry and conservation areas, although there was some variation in detail. Both NSW NPWS and SFNSW observed high numbers of fires and a high proportion of deliberate fires in reserves under their jurisdiction where deliberate firesetting was a problem.
- Deliberate firesetting was also an important factor in fires in the Outback and Riverina regions although in these two instances intensive and localised cases of deliberate firesetting strongly affected the trends observed for the region as a whole.
- Natural causes accounted for a high proportion of fires land management agencies attended in the Explorer Country, Capital Country, Murray and Snowy Mountains regions.
- Land management agencies attended the greatest number of burn offs in the New England, Northern Rivers and Hunter and Mid North Coast regions. These regions also tended to experience the greatest number of illegal burn offs.
- Substantial differences can exist between the principal causes of fires in urban and in rural (including land management tenures) areas within the same region. Differences in specific causes of deliberate fires (for example, illegal burns versus malicious incendiarism) can also arise.
- Overall, there was strong correlation between the number of **non-deliberate child fires** and the total number of fires within a given area, and for a given year; specifically, non-deliberate child fires accounted for the highest proportion of fires in the Sydney and New England–North West regions (20%).
- Most **smoking-related fires** occurred in the Sydney (57%), Illawarra (11%) and Hunter (9.5%) regions; percentages of smoking-related fires were highest in the Illawarra (9.3%), Sydney (8.1%), and the Murray (8.6%) regions.

- Individual postcodes commonly experienced between one and 100 fires of any cause, and between 0.1 and 100 deliberate fires per 10,000 people per year. The maximum recorded rates were comparatively uniform across populations ranging from 100 to 100,000 people. Higher rates were evident in southwest Sydney compared to other areas in the region.

Timing: Important aspects of the timing of vegetation fires in New South Wales are summarised in terms of the time of the year, day of the week and the time of day at which they occurred.

Week of the year: NSW experienced the highest numbers of vegetation fires from mid-July to the end of March, but there were two dominant populations: early season fires (mid August to mid November – late winter and spring) and peak season fires (mid-December–January – summer). The proportion of early season to late season fires varied between agencies, regions, and seasons, reflecting differences in principal causes of fire, the types of environment in which fires occurred, and differing climatic/weather conditions. Most natural fires occurred in the peak season, irrespective of the fire agency concerned. However, large numbers of natural fires occurred earlier in 2002–03, and to a lesser extent 1997–98 (SFNSW); that is, in years associated with El Niño-like weather patterns. Some differences were evident in the timing of fires across agencies, namely:

- **NSWRFS**: A high proportion of all NSWRFS fires occurred during the early season. Greater numbers of accidental fires occurred during the early season compared with the peak season, reflecting the high contributions from burn offs within this category. The numbers of deliberate fires were comparable between early and peak seasons, but deliberate fires comprised a higher proportion of all fires during the peak season; the cause of a high proportion of fires during the early season was unknown. However, some differences may exist in the types of deliberate fires lit during peak and early seasons.
- **NSWFB**: The NSWFB attended a greater proportion of peak season fires than did other fires agencies. The timing of accidental and deliberate fires was comparable. The Sydney, Hunter, Illawarra and Central Coast regions all experienced peaks in fire numbers during both the peak and early seasons. High numbers of peak season fires occurred in all these regions, being most pronounced for 2001–02. Most fires in northern NSW occurred during the early season, but higher than normal numbers of fires occurred during the peak season in 2001–02. In contrast, the Murray, Riverina and to the less extent the Explorer Country regions experienced greater numbers of fires in the peak season.

NSW NPWS: The balance of early and peak season fires varied markedly between years, depending on the number and timing of natural fires. Overall most deliberate fires occurred during the early season, overlapping with but also post-dating the timing of burn offs. Large numbers of peak season fires primarily occurred in the Sydney and surrounds region and the Hunter–Mid North Coast region

- **SFNSW**: Most deliberate fires occurred during the early season, coincident with the timing of rural burns; large numbers of deliberate fires during the peak season were principally restricted to 2001–02.

Day of the week: Variations in fires by day of the week are described below:

- **NSWRFS**: Thirty percent of fires occurred on Saturday and Sunday relative to the average weekday; the incidence of weekend cause-specific fires were incendiary, 50 to 55 percent more likely; suspicious, 23 to 30 percent more likely; accidental, 33 to 37 percent more likely. High proportions of weekend fires occurred in the Sydney (39 to 49% higher), Blue Mountains (45 to 65% higher), Illawarra, North Coast, and Outback commonly 30% to 50% higher) regions.
- **NSWFB**: NSWFB-attended fires were 30 percent more likely to occur on Saturday and 28 percent more likely on Sunday than on the average weekday but were cause specific (incendiary, 40% higher; suspicious, 29 to 32% higher; and accidental 29 to 34% higher on weekend days) and varied between regions.

- **NSW NPWS** and **SFNSW**: No weekend bias was observed.

Time of the day: Information about the detection times of fires for the NSWRFS, NSWFB and SFNSW are summarised below:

- **NSWRFS**: The incidence of deliberate and natural fires peaked between 3 and 5 pm; accidental, other and reignition peaked between 1 and 2 pm; 32 percent of suspicious fires occurred between 6 pm and 6 am compared with 18 percent for accidental fires; 13 percent of suspicious fires occurred between 10 pm and 6 am compared with five percent of accidental fires. A high proportion of night-time fires occurred in the Riverina and Outback regions.
- **NSWFB**: Peak numbers of fires occurred between 3 pm and 7 pm. Although the peak for non-deliberate fires was slightly earlier than for deliberate fires, it is noted that the peak for accidental fires is slightly later than in many other jurisdictions. Peak numbers of fires also occurred earlier on weekends. A higher proportion of deliberate fires occurred at night compared with other fire causes; 33 percent of deliberate fires occurred between 7 pm and 5 am, compared with 26 percent of accidental fires. Greater numbers of deliberate fires occurred on Friday night–Saturday morning and Saturday night–Sunday morning. However, the dominant timing of fires varied both between and within regions.
- **SFNSW**: No substantial differences were evident between the times fires occurred, but detection times appear to have been shaped by the time during which staff were on duty.
- **Non-deliberate child fires**: The distribution of non-deliberate child fires by week of the year parallels that observed for fires generally within each region. Overall, non-deliberate child fires were 36 to 42 percent more likely to occur on weekend days. Numbers peaked between 3 and 6 pm on weekdays, but somewhat earlier on weekends. One-quarter of all child fires occurred between 7 pm and 5 am, with the proportion of night-time fires increasing with age of the child.

Area burned: Most fires were small, with the number of fires decreasing with increasing fire size. A higher proportion of SFNSW-attended fires were of a moderate to large size, compared to other NSW fire agencies.

Overall, deliberate fires accounted for a decreasing proportion of fires, as fire size increased, although this relationship breaks down for large fire sizes. Natural fires and to some extent rural burns/burn offs accounted for higher proportion of all moderate and large fires.

The size distributions for individual regions were related to the principle cause of fires in those regions. For example, a high proportion of the moderate to large fires the NSW NPWS attended occurred in the New England region owing to the greater numbers of burn offs, whereas the Sydney region accounted for a high proportion of small fires (owing to the high density of small deliberate fires) and a high proportion of larger fires (many of which were natural in origin).

For the NSW NPWS, natural fire causes were a significant contributor to large fires that started on, and subsequently escaped from, NSW NPWS' tenure, whereas many large deliberate fires originated outside of and subsequently spread onto NSW NPWS tenure.

All three regional agencies recorded the greatest total areas burned in 2002–03 followed by 2001–02 and 2000–01; natural ignition was the principal cause of the large areas burned in 2002–03, whereas large fires in 2001–02 resulted from both natural and deliberate causes. Most large deliberate fires in 2001–02 were identified as suspicious, as opposed to positively being identified as incendiary.

Large areas were burned in NSW every year during the early season; illegal and legal burns were major contributors to the total area burned during this time. NSW NPWS records indicated that greater areas of land were burned by illegal causes (principally illegal burns) in 2000–01 than during 2001–02. The ratio of area burned by illegal burns, relative to burned in legal burns has systematically decreased since that time. SFNSW still recorded large areas burned in rural burns during 2002–03, although there was no indication if these fires were legal or illegal.

The most devastating fire seasons, namely 2001–02 and 2002–03, were both characterised by large fires during the peak season (mid December and January); deliberate (suspicious) causes, along with fires of natural origin were an important contributor to the large areas burned during 2001–03; large areas were not burned by deliberate fires during 2002–03, despite the severity of the season.

In relation to fires during adverse fire seasons, it is noted that:

- the 2001–02 season was not particularly remarkable in terms of the overall number of deliberately lit fires, either on a state-wide scale or within the particular regions most adversely affected by the 2001–02 fires
- small increases in the numbers of deliberate fires during the 2001–02 and 2002–03 seasons may imply some deliberate firesetting specifically targeting adverse fire weather, but absolute numbers of such fires are likely to be low
- regions most affected by the 2001–02 fires, including the Hunter, Central Coast, North Coast, Illawarra and to some degree Sydney, all reported high levels of deliberate firesetting generally; in most instances, this problem existed before 2001–02, being evident as early as 1997–98 in some areas
- all three regional agencies recorded a decrease in large deliberate fires during December–January since the 2001–02 fires.

Sources of background information

ABS 2001a. *Australian standard geographical classification*. ABS cat. no. 1216.0. http://www.abs.gov.au/ausstats/abs@.nsf/cat/1216.0

ABS 2001b. *Postal area to statistical local area concordance, Australia, 2001*. ABS cat. no. 1253.0. http://www.abs.gov.au/ausstats/abs@.nsf/cat/1253.0

ABS 2005a. *Population by age and sex, New South Wales*. ABS cat. no. 3235.1.55.001. http://www.abs.gov.au/ausstats/abs@.nsf/cat/3235.1.55.001

ABS 2005b. *Tourism region maps and concordance files, Australia, 2005*. ABS cat. no. 9503.0.55.001. http://www.abs.gov.au/ausstats/abs@.nsf/cat/3235.3.55.001

ABS 2006. *Australian demographic statistics*. ABS cat. no. 3101.0. http://www.abs.gov.au/ausstats/abs@.nsf/cat/3101.0

AIC 2005. Causes of investigated fires in New South Wales. *BushFIRE arson bulletin* 21. http://www.aic.gov.au/publications/bfab/bfab021.html

APC 2006. *Report on government services 2006, part D: emergency management*. http://www.pc.gov.au/gsp/reports/rogs/2006/emergencymanagement/index.html

Australia. Department of Environment and Heritage 2001a. *Land use: New South Wales*. Accessed through: http://audit.deh.gov.au/ANRA/atlas_home.cfm

Australia. Department of Environment and Heritage 2001b. *Native vegetation types and extent: New South Wales*. Accessed through: http://audit.deh.gov.au/ANRA/atlas_home.cfm

Australia. Department of Environment and Heritage 2001c. *Human settlements theme report*. Accessed through: http://audit.deh.gov.au/ANRA/atlas_home.cfm

Australian Bureau of Meteorology 2007a. *Average minimum and maximum temperature maps: New South Wales*. Accessed through: http://www.bom.gov.au/climate/map/temperature/IDCJCM0005_temperature.shtml

Australian Bureau of Meteorology 2007b. *Average rainfall, annual: New South Wales*. Accessed through: http://www.bom.gov.au/cgi-bin/climate/cgi_bin_scripts/annual-monthly-rainfall.cgi

Australian Bureau of Meteorology 2007c. *Fire seasons in Australia*. http://www.bom.gov.au/climate/c20thc/fire.shtml

Ellis S, Kanowski P & Whelan R 2004. *National Inquiry into Bushfire Mitigation and Management*. Canberra: Commonwealth of Australia. http://www.coagbushfireenquiry.gov.au/findings.htm

EMA 2006a. *Emergency management database: January 1939 bushfires*. http://www.ema.gov.au/ema/emadisasters.nsf/6a1bf6b4b60f6f05ca256d1200179a5b/f3b24a29f0055fb2ca256d3300057c33?OpenDocument

EMA 2006b. *Emergency Management Database: November 1968 bushfire*. http://www.ema.gov.au/ema/emadisasters.nsf/c85916e930b93d50ca256d050020cb1f/847e188017d38b88ca256d3300057ba2?OpenDocument

EMA 2006c. *Emergency Management Database: Summer 1993–94 bushfires*. http://www.ema.gov.au/ema/emadisasters.nsf/c85916e930b93d50ca256d050020cb1f/4d5460c3947cc6faca256d3300057c06?OpenDocument

NSW NPWS 2007. *Parks and reserves: find a park*. http://www.nationalparks.nsw.gov.au/parks.nsf

NSWRFS 2001. *Christmas 2001 bushfires: information and statistics*. http://www.bushfire.nsw.gov.au/file_system/attachments/State/Attachment_20050308_DDBF2C8D.pdf

NSWRFS 2003. *2002–2003 fire season statistics*. http://www.bushfire.nsw.gov.au/file_system/attachments/State/Attachment_20050308_AD19D2F9.pdf

Victoria

Contents

The first part of this chapter provides **contextual information** on Victoria, including basic information about its climate, geography, land use and population. It also provides an outline of the bushfire regimes, historically important bushfire events, and an overview of fire services in Victoria. The second part represents an **analysis of data** provided by the Metropolitan Fire and Emergency Services Board, the Country Fire Authority and the Department of Sustainability and the Environment. Although data supplied for the Metropolitan Fire and Emergency Services Board included all categories of fires, this analysis exclusively refers to vegetation fires, unless otherwise indicated.

For an explanation of the key terms, limitations and methodology refer to the introduction, glossary and methodology chapters.

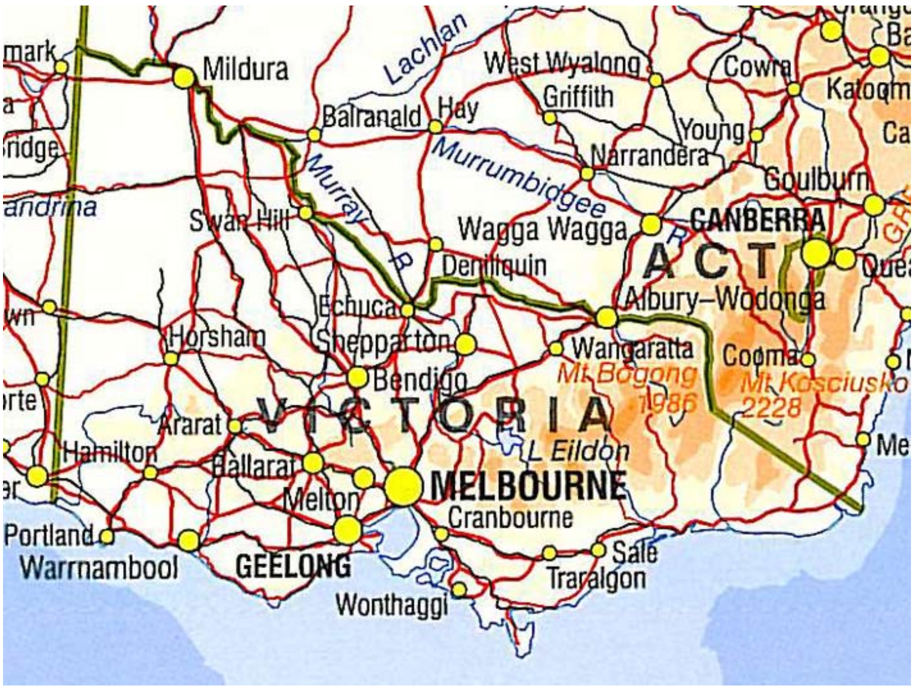
Introduction

Victoria is in southeastern mainland Australia (Figure 1), bordered by New South Wales to the north and South Australia to the west. It is Australia's smallest mainland state, covering an area of 237,629 square kilometres.

Geography

Victoria is topographically, geologically and climatically diverse. The Great Dividing Range, which stretches along Australia's east coast, forms the prominent geographical feature, rising to almost 2,000 metres at Mount Bogong and terminating to the west of Ballarat (Figure 1). The range effectively divides the state into three climatic zones: southern and coastal areas, alpine areas, and semi-arid plains to the west and northwest. Coastal regions are temperate and cool, and comparatively wet, whereas the northwest (Mallee and Upper Wimmera) can be hot and dry owing to the hot winds that blow from the nearby deserts. The Alps are cool to cold, with the highest parts averaging below 0°C in winter. The Alps are the site of some of Australia's premier ski resorts.

Figure 1: Map of Victoria

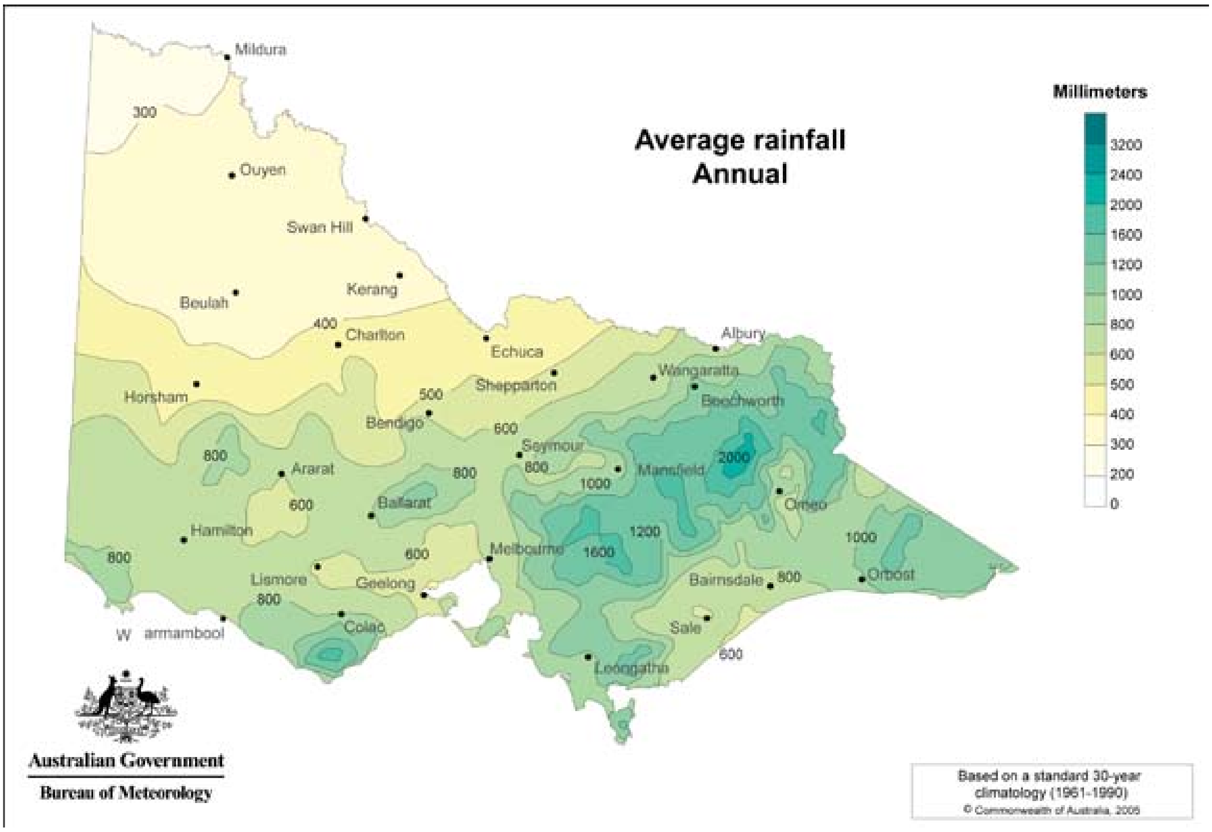


Climate

Victoria is the wettest state in Australia after Tasmania, but rainfall is highly variable across the state. Overall, precipitation increases from north to south, with the highest falls occurring at high altitudes. Some parts of the northeast record more than 1,800 mm of precipitation per year (Figure 2). In most of the state, precipitation principally falls as rain, whereas snow is common along the Alps in winter.

Rainfall principally occurs in winter, being associated with the movement of moisture-laden air in cold fronts, from the Southern Ocean. The most reliable rainfall occurs close to the coast, in the Gippsland and Western regions, making these the richest agricultural lands. In contrast, parts of the northwest, in the Mallee and to a lesser extent Wimmera, receive less than 250 mm (Australian Bureau of Meteorology 2007).

Figure 2: Annual average rainfall for Victoria

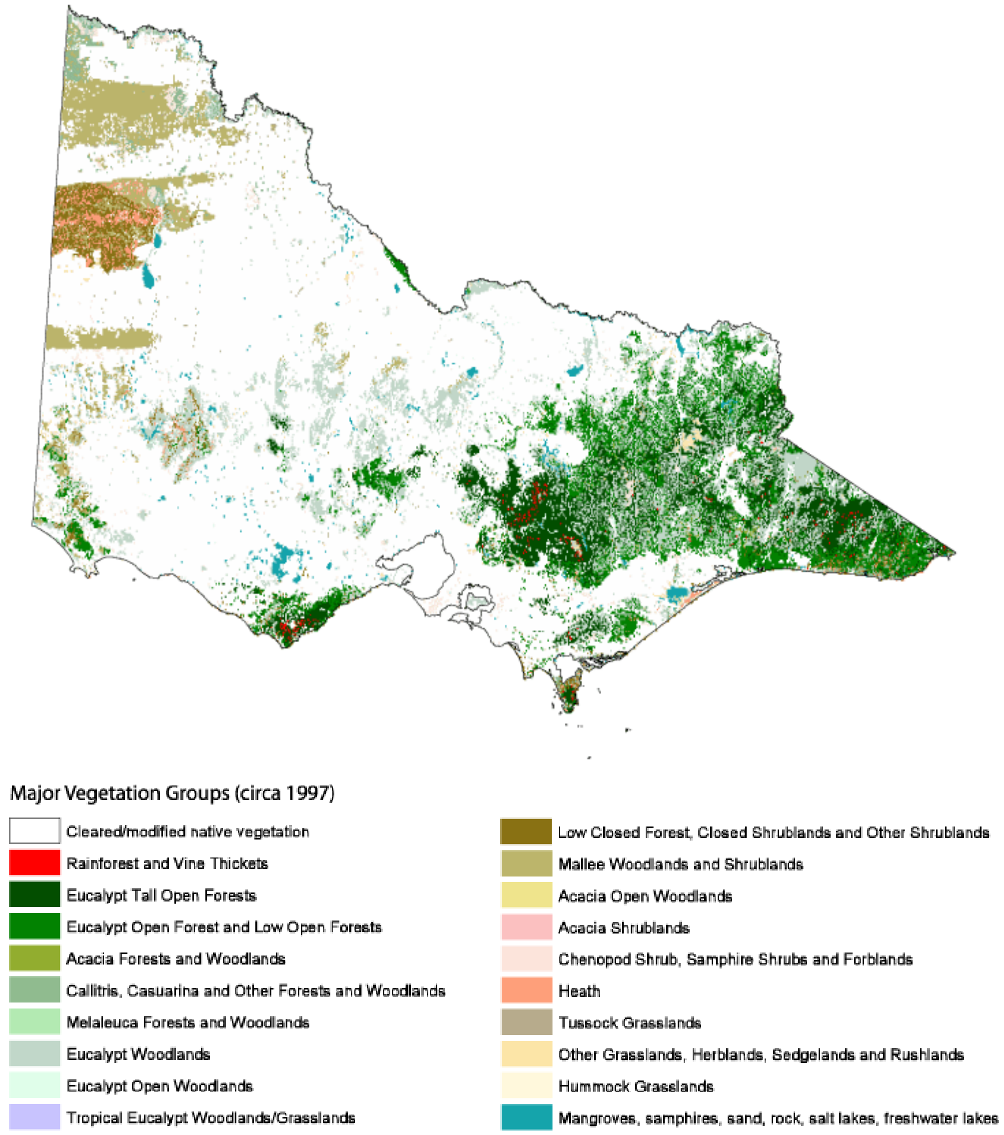


Source: Australian Bureau of Meteorology 2007

Native vegetation

Much of Victoria's native vegetation has either been cleared or markedly modified to make way for agriculture (Figure 3). The remainder is highly diverse. The highest density of native vegetation occurs in the mountain ranges and nearby coastal plains of the northeast. There are extensive eucalypt tall open forests (trees rising to 90 m high), eucalypt open forest and low open forest in the southern ranges and plateaus. Eucalypt woodlands dominate the hot, dry plains. In the arid northwest, mallee eucalypt woodlands and shrublands dominate. There are also extensive coastal heaths and wetlands. Alpine herb fields and bogs covered by winter snows occur in the highest reaches of the Great Dividing Range, in the northeast. Small pockets of rainforest are dispersed among the eucalypt forests of the northeast and southern Victoria (Australia. Department of Environment and Heritage 2001b).

Figure 3: Native vegetation groups (c. 1997)



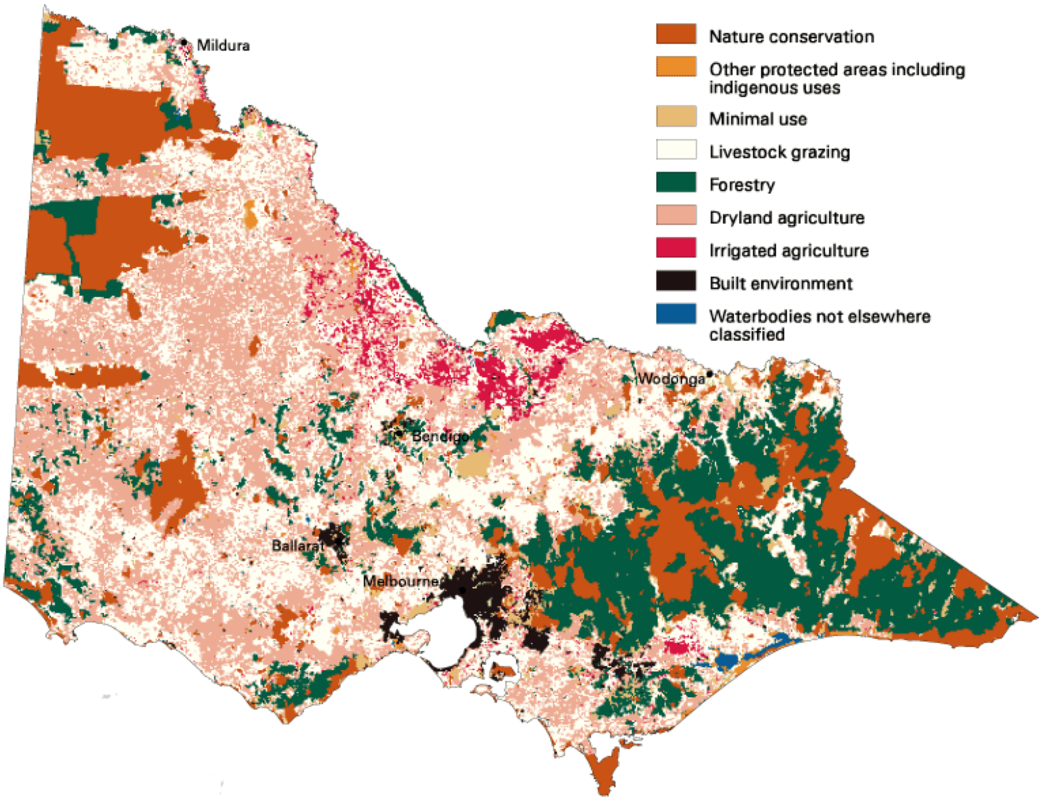
Source: Australia. Department of Environment and Heritage 2001b

Land use

In 1996–97, agricultural activity accounted for 61 percent of the state's land use. Livestock grazing is commonly interspersed with dryland farming along much of the southern coast, and in central and western Victoria (Figure 4). Irrigated agriculture principally occurs in central northern Victoria, using waters from the Murray River, which defines the northern border of the state. The principal agricultural products of Victoria include wool, lamb/mutton, beef, wheat, oats, barley, maize, tobacco, hops and fodder crops, citrus, grapes, apples, stone fruits, vegetables and dairy products.

Forestry, which is concentrated in the state's northeast, accounted for nearly 17 percent of the total area in 1996–97, with a further 15 percent reserved for nature conservation (Australia. Department of Environment and Heritage 2001a).

Figure 4: Land use (c. 1996–97)



Source: Department of Environment and Australia. 2001a

Population

Victoria is the most densely populated and urbanised state in Australia. Although the state is geographically small, in June 2006 the residential population was estimated to be 5,091,666; 24.7 percent of Australia's population (ABS 2006). Nearly 90 percent of people live in cities or towns. Almost three-quarters (72% in 2005) live in the capital, Melbourne. Other important regional urban centres include Geelong, Ballarat, Bendigo, Shepparton, Mildura, and Warrnambool. Approximately 72 percent of Victoria's population was born in Australia, with less than one percent identifying as Indigenous. People who were not born in Australia commonly came from the United Kingdom, Italy, Vietnam, Greece or New Zealand.

The median age of Victoria's population was 36.8 years in 2005, compared with the national average of 36.6. The median age in the Melbourne statistical division (SD) was 36.0 years whereas the median age in regional Victoria (all SDs excluding Melbourne) was 39.1 years (ABS 2005a).

Children aged 0 to 14 years comprised 19.1 percent of Victoria's population in June 2005, compared with the national average of 19.6 percent. Despite a lower median age, children 0 to 14 years comprised 18.6 percent of the Melbourne SD population, but 20.3 percent of the population of the remainder of state. The highest proportion of children (0 to 14 years) occurred in the Mallee (21.7%), Goulburn (21.2%) and Western District (21.2%) SDs (ABS 2005a).

Bushfire regimes

The bushfire season in Victoria normally extends from November to April, coinciding with hot and dry conditions that dominate the summer months across much of the state. The extent and severity of bushfires are highly variable from year to year.

Bushfire history

Victoria has been subjected to some of the most devastating bushfires in Australia's history, in terms of both area burned during a single fire event, and loss of property and life. More than 300 people have died in Victorian bushfires, more than the loss of life in all other states and territories combined. Major bushfire events are listed in Table 1, with selected bushfires discussed in detail below.

1851: Black Thursday, 6–10 February – This fire, which is captured in an oil painting by William Strutt, was the largest (in terms of area burned) recorded in Victoria's history. Unofficial records indicate temperatures in Melbourne on 6 February had reached 47°C by 11 am. The bushfires consumed five million hectares (50,000 square kilometres) or nearly one-quarter of the state's land area, burning bush from Barwon Heads to Mount Gambier in South Australia, affecting Portland, Plenty Ranges, Westernport, the Wimmera and Dandenong. Emergency Management Australia's records indicate that 15 people died and 150 were injured, 1,300 buildings were destroyed and 1.1 million livestock died (EMA 2006a).

1939: Black Friday, (13 January), December 1938 to January 1939 – The bushfire that culminated in Black Friday was the worst in Victoria's history in terms of loss of life. The summer of 1938–39 was hot and dry, and by early January several fires were burning. Northeasterly winds associated with dry, heat wave conditions caused several fires to combine into a single massive front. The effects of fire were widespread. The most damage was in the alpine areas, and in the Otway and Yarra Ranges, with the Acheron, Tanjil and Thomson Valleys, and the Grampians also hit. The townships of Narbethong, Nayook West, Noojee and Woods Point were all destroyed and not rebuilt; Omeo, Pomonal, Warrandyte and Yarra Glen were all badly damaged. The confluence of two fire fronts near Warrandyte put suburban Melbourne under threat. The Royal Commissioner leading an investigation after the fires noted that 'it appeared the whole state was alight on Friday, 13 January 1939'. The fires burned between 1.5 and 2 million hectares, including 800,000 hectares of protected forest, 600,000 hectares of reserved forest and 4,000 hectares of plantations; and they destroyed 1,300 buildings, including more than 650 homes, shops, 69 timber mills, and hospitals. The fires resulted in the deaths of 71 people and the loss of huge numbers of stock. After the Royal Commission, Judge Stretton said in his report '... it will appear that no one cause may properly be said to have been the sole cause ...', but human actions played an important role. Burning off for land clearing and grass growth, lighting campfires, inappropriate sawmill operations and domestic fires, by landowners, graziers, miners, forest workers and campers before the fires had all played a part (DSE 2007c, EMA 2006b).

1943–44: late December to mid February – Numerous fires occurred, particularly around the western, central and southern portions of the state. On 22 December, hundreds of hectares of grassland burned near Wangaratta, killing 10 people. Other fires occurred at Beaumauris (Melbourne), and in the Gippsland region (Morwell and Yallourn). The fires of 1943–44 resulted in the deaths of 51 people, loss of 58 homes and over 600 other buildings, as well as major stock losses (EMA 2006c).

1969: 8 to 9 January – Fires in central and southern Victoria killed 23 people and injured a further 100. The worst hit area was at Lara, where an enormous, fast-moving grassfire approached the four-lane Melbourne–Geelong Expressway. The dense smoke caused some motorists to halt; those who stayed in their cars with the windows closed were able to leave when the smoke became less dense. Six people who did this were known to have survived, however, 17 people who abandoned their cars and attempted to outrun the fire, died; eight at the scene, two on the way to hospital, and seven in hospital. Fires also resulted in deaths north of the Great Dividing Range. Other fires affected Daylesford, Bulgana, Yea, Darraweit, Kangaroo Flat and Korongvale. The bushfire resulted in the loss of 230 homes and 21 schools/churches/halls. Approximately 250,000 ha were burned and 12,000 stock were lost (EMA 2006d).

1983: Ash Wednesday – 16–18 February – An El Niño event led to a severe drought over much of Australia during 1982–83, with Victoria recording little rainfall in the previous 10 months. Summer rainfall for Victoria was up to 75 percent less than in previous years. Large fires started in late November, and in early January and February. Movement of a cold front in South Australia forced hot air from central Australia into Victoria, generating hot conditions with low humidity. On the preceding day winds had whipped up huge dust storms. At this point, the fires moved along in narrow tongues. However, with a wind change, these fires suddenly spread, burning across a wide front and resulting in large loss of life and property across many parts of Victoria (*see also* South Australian Ash Wednesday fires). The most severely affected areas in Victoria included Cudgee–Ballangeich, East Trentham–Mount Macedon, Otway Ranges, Belgrave Heights–Upper Beaconsfield, Cockatoo, Monivae, Branxholme, and Warburton. Approximately 210,000 hectares burned, 47 lives were lost, and 2,080 homes burned; there were also losses of businesses, stores, equipment, machinery, stock and other private assets. Property damage resulted in losses of over $200 million. Approximately $50 million was lost in timber resources. The fires were attributed to numerous causes, including power lines and deliberate actions (DSE 2007b, EMA 2006e).

2002–03: – Thunderstorm activity on 7–8 January started a series of fires in Victoria, before moving into and triggering devastating fires in southern New South Wales and the Australian Capital Territory. In Victoria, the fires were principally in Gippsland and the northeast. The alpine fires continued over 59 days, burning one million hectares of public land and 100,000 ha of private land; they destroyed 41 houses, 213 other structures, 3,000 km of fencing, and resulted in the loss of more than 9,000 head of stock. A further 181,400 ha burned in the Big Desert fires (17 to 25 December) in the state's northwest. One firefighter died in that fire, although it was not the direct result of firefighting (Ellis, Kanowski & Whelan 2004).

2006–07: Approximately, 1,000,000 ha in the northeast and Gippsland were burned in December and January; in many cases in areas already affected by the 2002–03 fires.

Table 1: Fire history in Victoria

Date	Deaths	Area of fire (ha)	Losses	Location(s)
1851 February (Black Thursday)	Approx. 12	5,000,000; one-quarter of Victoria	1 million sheep, thousands of cattle	Wimmera, Portland, Gippsland, Plenty Ranges, Westernport, Dandenong district, Heidelberg
1898 February (Red Tuesday)	12	260,000	2,000 buildings	South Gippsland
Early 1900s (esp. 1905, 1906, 1912, 1914)		Varied (100,000 in 1914)		Gippsland, Grampians, Otway Ranges
1926	60		Many farms and homes	Noojee, Kinglake, Warburton, Erica, Dandenong Ranges
1932	9			Many districts across Victoria, particularly Gippsland
1938–1939 December–January (incl. Black Friday)	71	1,520,000	>650 homes and shops, 69 timber mills	Large areas of the northeast and Gippsland, the Otway and Grampian Ranges, and the towns of Rubicon, Woods Point, Warrandyte, Noojee, Omeo, Mansfield, Dromana, Yarra Glen, Warburton, Erica
1942 March	1		100 sheep, 2 farms, >20 homes	Hamilton, South Gippsland – Yarram (burning on a 96 km front)

Table 1: Fire history in Victoria (continued)

Date	Deaths	Area of fire (ha)	Losses	Location(s)
1943 December	10			Wangaratta
1944 January	49	>1,000,000	500 homes, huge stock losses	Central and Western Districts
1944 February			Plant works, open-cut mine and buildings	Morwell, Yallourn
1952 February	Several	100,000		Benalla area
1962 January	>8		454 homes	The Basin, Christmas Hills, Kinglake, St Andrews, Hurstbridge, Warrandyte, Mitcham
1965 January	7		6 homes	Longwood
1965 February–March		300,000 forest 6,070 grassland	>60 homes and shops >4,000 stock	Gippsland
1968 February		1,920	64 homes and other buildings	Dandenong Ranges, The Basin, Upwey
1969 January	22	250,000	230 homes, 21 schools/ church/hall, >12 000 stock	280 fires broke out, affecting Lara, Daylesford, Bulgana, Yea, Darraweit, Kangaroo Flat, Korongvale
1972 December		12,140		Mount Buffalo
1977 February	4	103,000	More than 100 houses and shops, approx. 200,000 stock	Penshurst, Tatyoon, Streatham, Creswick, Pura Pura, Werneth, Cressy, Rokewood, Beeac, Mingay, Lismore, Little River
1978 January	2		1 house; 6,500 stock	Bairnsdale
1980–81 January–December		119,000		Sunset Country and the Big Desert
1983 January – February[a]	47	461,864	47 people died; >27,000 stock lost; 1,719 houses, 82 commercial properties, and 23 dairies burned; 1,238 farms damaged	Cann River, Mount Macedon, Monivae, Branxholme, Cockatoo, East Trentham, Otway Ranges, Belgrave Heights, Warburton, Cudgee, Upper Beaconsfield, Framlingham
1985 January	3	50,800	182 homes, 400 farms, 46,000 stock	Avoca–Maryborough, Little River, Springfield, Melton
1990 December	1		17 homes >12,000 stock	Strathbogie
1995 February		10,000 (mostly forest)		Berringa
1997 January	3	400	41 houses	Dandenong Ranges, Creswick, Heathcote, Teddywaddy, Gough's Bay
1997–98 December–January		32,000		Caledonia River area of Alpine National Park, Carey River State Forest
1998 December	5 (CFA firefighters)	780	1 CFA tanker	Linton
2000 December		29,000		Dadswells Bridge
2002 December		181,400	1 abandoned house	Big Desert
2003 January–March	1 indirectly	1,100,000	41 houses; 9,000 livestock	Over 80 fires started by lightning; northeast Victoria, Gippsland

a: losses derived from EMA 2006e

Source: Ellis, Kanowski & Whelan 2004

Fire services

Three major agencies provide fire services in Victoria. They are the Metropolitan Fire and Emergency Services Board, the Department of Sustainability and the Environment and the Country Fire Authority.

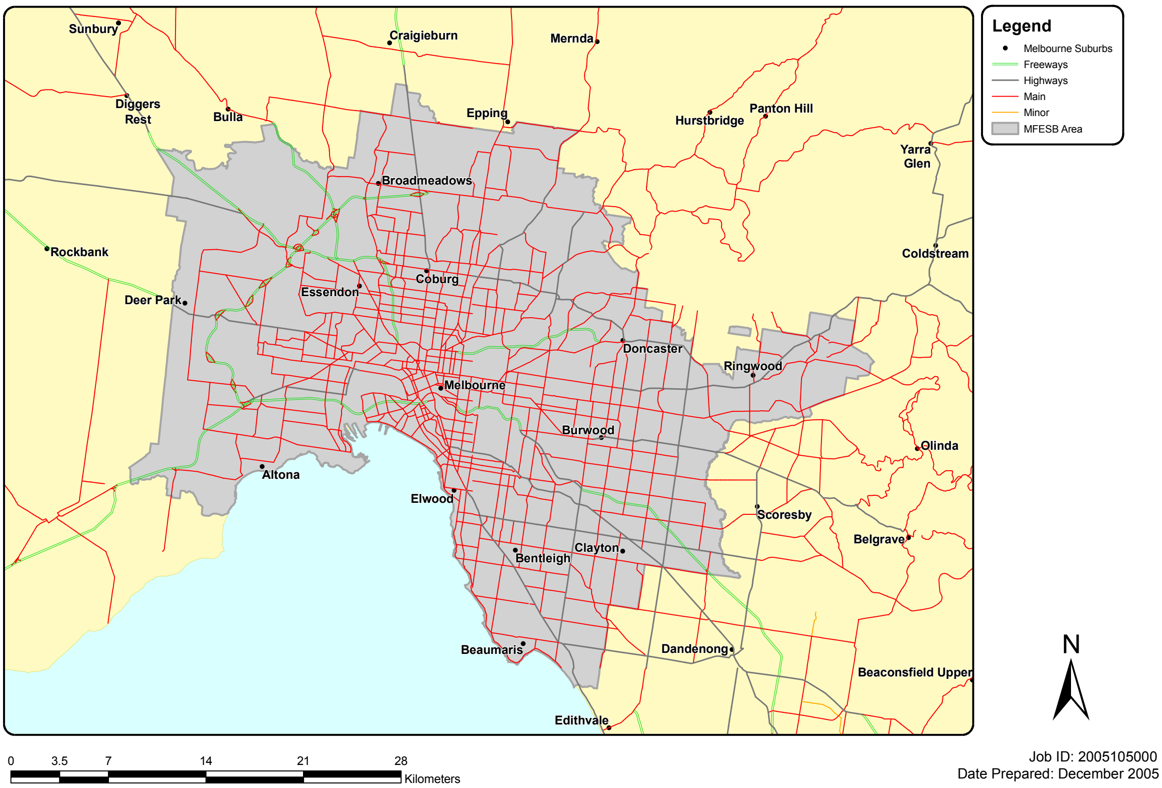
The **Metropolitan Fire and Emergency Services Board (MFB)** provides emergency response for all types of fire, urban search and rescue, high angle and road accident rescue, industrial accidents and hazardous materials incidents/handling, among other tasks, to the vast majority of the Melbourne metropolitan area (Figure 5). It employs 1,600 career firefighters, working from 47 stations (MFB 2007). The MFB data used in this analysis were sourced from the Australian Fire Authorities Council's (AFAC's) Australian Incident Reporting System (AIRS) database, and span 1997–98 to 2001–02. Further information about the MFB can be found at http://www.mfb.vic.gov.au.

The **Department of Sustainability and the Environment (DSE)** attends fires on public land and adjacent private property where fires threaten public land. Land under DSE jurisdiction is largely denoted as forestry and nature conservation in Figure 4. The DSE data analysed in this report is principally from 1993–94 to 2003–04, but where possible includes data from previous studies to extend the study from 1975–76 to January 2005. Further information about the DSE can be found at http://www.dse.vic.gov.au.

The **Country Fire Authority (CFA)** has responsibility for all fires (structural, bushfire/vegetation, vehicle fires etc.), as well as incidents involving hazardous materials, and road accident rescue that occur in urban and rural areas outside MFB and DSE jurisdiction; that is, in outer metropolitan Melbourne, regional urban centres and rural areas. The CFA may attend fires within DSE and, to a lesser extent, MFB jurisdictions, and visa versa. Further information can be found at http://www.cfa.vic.gov.au.

In instances where more than one fire agency attends a single fire, that fire would normally be recorded in each agency's database. This is most likely for large fires, and within the CFA and DSE datasets. It is unlikely to markedly affect the total number of fires recorded for a particularly period but will strongly affect the total area burned.

Figure 5: Jurisdiction of the Metropolitan Fire and Emergency Services Board and the Country Fire Authority in the Melbourne metropolitan region



Source: CFA 2007

Metropolitan Fire and Emergency Services Board

Background information about the MFB dataset and its analysis

Important information about the MFB dataset and the methodology employed to analyse it is summarised as:

- The data were sourced from Australasian Fire Authorities Council (AFAC).
- The dataset provided included all fires (structural, vehicle, vegetation, other fires); vegetation fires (AIRS wildfires; incident code 160 to 179) were extracted from this dataset. Hence, all references to 'fire' or 'fires' in this analysis refer to vegetation fires unless otherwise indicated.
- The dataset included fires from 1997–98 to 2001–02; the 1997–98 data were, however, incomplete, with vegetation fires having only been recorded from mid November (week 46) onwards.
- The database used AIRS classification codes.
- The cause was based on the ignition factor variable.
- Deliberate vegetation fires refer to all vegetation fires classified as incendiary (AIRS ignition factor code = 110 or 120) or suspicious (AIRS ignition factor code = 210 or 220).

- Natural vegetation fires refer to all fires where the ignition factor codes were 800 to 890, which incorporate any fire resulting from a natural condition or event. For the MFB the breakdown of specific causes of natural fires was; high wind 17.6 percent, lightning 11.8 percent, high water (including flood) 3.3 percent, and any other natural condition (not classified [NC]/insufficient information to classify further [IO]) 67.2 percent.
- Information about form of heat of ignition was supplied.
- Smoking-related vegetation fires were classified on the basis of:
  Form of heat of ignition = 'Heat from smokers' materials' (AIRS codes 300 to 390); the causal classification of smoking-related vegetation fires was 90 percent accidental, 0.3 percent incendiary, seven percent suspicious and two percent unknown.
- All vegetation fires attributed to children and discussed in the text were classified accidental in origin; deliberate vegetation fires started by children were classified as incendiary or possibly suspicious and therefore cannot be delineated from other incendiary or suspicious fires. Some information about the age of children was supplied but was incomplete.
- The dataset included information about 'type of incident'.
- The regions used in the MFB analysis (pertinent to the combined MFB–CFA analysis only) were based on the tourism regions defined by the Australian Bureau of Statistics (2005b). Assignation to regions was based on the postcode variable provided. There was not an exact concordance between the postcode and tourism regions. The ABS defines tourism regions based on smaller statistical areas. Hence, ABS tourism regions potentially crosscut suburbs and postcodes. In this study, assignation was based on the highest levels of concordance between postcodes and tourism regions. Hence, there is not an exact correspondence between tourism regions used in this analysis and ABS tourism regions.
- Statistical local areas (SLA) were generated using the greatest levels of concordance between postcodes and SLAs (ABS 2001b). Statistical subdivisions (SSD) were generated from these SLAs using the ABS, Australian Standard Geographical Classification (ABS 2001a). Again, there was not an exact correspondence between SLAs, SSDs used in this analysis, and those defined by the ABS.
- The dataset included information about the area burned.
- Information was available about fire restrictions or fire danger index.

For more detail about these methodologies see the methodology chapter.

Overview

Fires the MFB attended can be summarised as follows:

- The MFB attended 9,543 vegetation fires between 1997–98 and 2001–02, representing an average of 1,909 vegetation fires per year (sd=375) and approximately one-quarter of all vegetation fires attended by fire agencies in Victoria each year. The number of vegetation fires varied from a low of 1,427 in 1998–99 to a high of 2,482 in 2000–01 (Figure 6).
- Vegetation fires were exclusively in metropolitan Melbourne; that is, they are largely urban vegetation fires – 63 percent were classified as small vegetation fires, 18 percent as grassfires, nine percent as mixed scrub/bush/grass fires, and nine percent as other vegetation/outside fires that were not classified/insufficient information to classify. These types of incidents are likely to include fires in the local parks or reserves, fires along roadways, rivers and creeks, pockets of remnant vegetation within and between suburbs. However, they may also include hedge fires, single tree/bush fires, fires on the local oval etc.

- A total of 5,800 ha was burned in metropolitan Melbourne in five years.
- Deliberate causes were responsible for 22.9 percent of fires (31% of known causes), and almost half of the total area burned.

Cause

Almost half of all vegetation fires in the Melbourne metropolitan district were attributed to accidental causes (Figure 7). Around twenty-three percent were deliberate, 1.5 percent incendiary and 21.4 percent suspicious. Natural causes were responsible for just 0.5 percent of fires. The cause of fires was unknown in around one-quarter of all cases (Figure 7). Deliberate causes accounted for 30.7 percent of known causes.

Annual variations in the number and proportion of deliberate fires were small (Figure 6). The number of deliberate vegetation fires ranged from a minimum of 300 in 1998–99 up to a maximum of 531 in 2000–01. Overall, there was a strong correlation between the number of deliberate vegetation fires and the total number of vegetation fires in a given year (r = .87), with the percentage of deliberate fires ranging from 21 percent in 1998–99 to 2000–01 to 26 percent in 2001–02. No net increase in the number or proportion of deliberate fires was evident over the interval examined. Similarly, the proportions of other fire causes remained consistent throughout the observation period (Figure 8).

Specific ignition factors

Form of heat of ignition: Open flames were found to be responsible for starting 31 percent of all vegetation fires, with a further 34 percent being smoking-related (cigarettes, cigars, etc.; Figure 9). Other known forms of heat of ignition comprised just 6.6 percent of cases. Of these, electrical equipment and a hot object/friction were the principal contributors.

Heat from an open flame contributed to both deliberate and non-deliberate vegetation fires, but accounted for a higher proportion of deliberate ones (Figure 10). More than three-quarters of all vegetation fires from an open flame were documented to have involved use of matches, with a further 7.8 percent involving use of a lighter (Figure 11). Fourteen percent of vegetation fires within the open flame category related to other (unspecified) causes. Burn offs, rubbish and campfires accounted for less than 1.5 percent.

Fires started by children: Children 16 years and younger were implicated in accidentally lighting 15.5 percent of vegetation fires in the Melbourne metropolitan area (Note: no information is available about the number of deliberate [incendiary and suspicious] vegetation fires started by children). In two-thirds of cases, the age of the child was unknown. Of the remaining one-third, the proportion of fires attributed to each age group increased with age; children 0 to 5 years, 6 to 12 and 13 to 16 years old accounted for 0.6, 10 and 25 percent of all child vegetation fires respectively (Figure 12). The number of fires started by children peaked in 2000–01, coinciding with the peak in MFB-attended vegetation fires generally. Overall, there was a significant correlation ($r=.89$; $p<.01$) between the number of vegetation fires lit by children and the total number of vegetation fires each year.

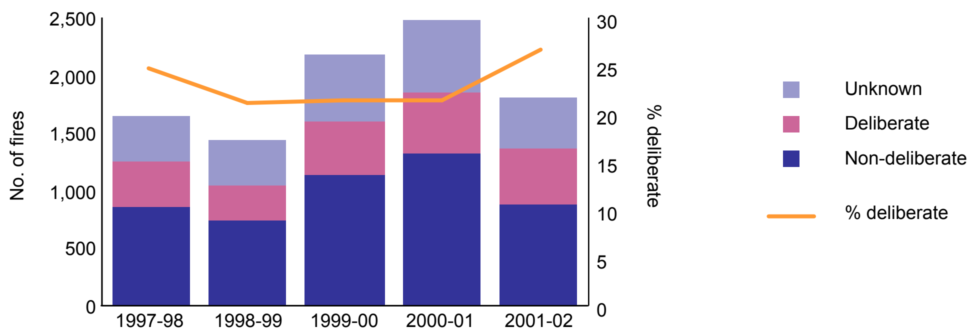
The majority of fires lit by children were started using the heat from an open flame. This occurred irrespective of the age group (Figure 13). However, for older age groups, additional factors like smoking-related materials and fireworks contributed to a higher proportion of fires. It was somewhat surprising that the highest proportion of smoking-related fires occurred for 6–12 year olds. Nevertheless, the greatest total number of smoking-related fires occurred for the 13–16 year age group. Of those fires started by open flames, the majority resulted from the use of matches and cigarette lighters, although lighters comprised a smaller proportion of accidental fires started by older children than for 0 to 5 year olds.

Smoking-related fires: Nearly one-third of all vegetation fires (31%; n=2922) the MFB attended were smoking-related (Figure 9). In this instance, smoking-related materials included cigarettes, cigars, pipes, and unspecified, other, or undetermined smoking materials. The numbers of smoking-related vegetation fires varied from 406 in 1998–99 to 767 in 2000–01 (Figure 14). The number of smoking-related vegetation fires was significantly positively correlated with the total number of vegetation fires each year ($r=.94$; $p<.01$). The proportion of smoking-related vegetation fires each year remained constant at 28 to 33 percent (Figure 14).

The MFB reported the highest proportion of smoking-related vegetation fires of any jurisdiction or agency in Australia. Several interconnected factors may affect this observation. First, the total frequency of vegetation fires, and the proportion of deliberate vegetation fires in the Melbourne metropolitan region is comparatively low. If the proportion of other causes is low, the proportion of smoking-related vegetation fires will necessarily be higher. Second, the restricted (metropolitan) jurisdiction of the MFB. The observation from other jurisdictions is that inner metropolitan areas are characterised by comparatively low rates of vegetation fires, lower proportions of deliberate vegetation fires, and higher rates of smoking-related fires. The proportions of deliberate and smoking-related vegetation fires are affected by the proportion of the jurisdiction that lies within an inner city, versus an interface-zone (I-zone), environment. Third, the MFB is the only agency in Australia restricted to a metropolitan area; most other agencies attend vegetation fires in all major regional urban centres, and in some cases, bushfires in more rural areas as well. Moreover, in Melbourne, many of the more distant locations closer to the I-zone fall within the Country Fire Authority's (CFA) jurisdiction. The proportion of smoking-related vegetation fires the MFB attended is comparable with the rate reported for Inner Perth.

There was a flow-on effect of high rates of smoking-related vegetation fires to causal classification schemes. In most instances, smoking-related fires were not labelled incendiary or suspicious within the ignition factor variable. Hence, the majority of smoking-related fires (90%; Figure 14) fall within the non-deliberate category based on the ignition factor code. Although technically they may have not been deliberately lit, it does not mean these fires were either legal or unavoidable. This needs to be considered when interpreting the MFB data. The issue of smoking-related fires needs be addressed alongside deliberate causes to reduce the number of human-caused vegetation fires in metropolitan Melbourne.

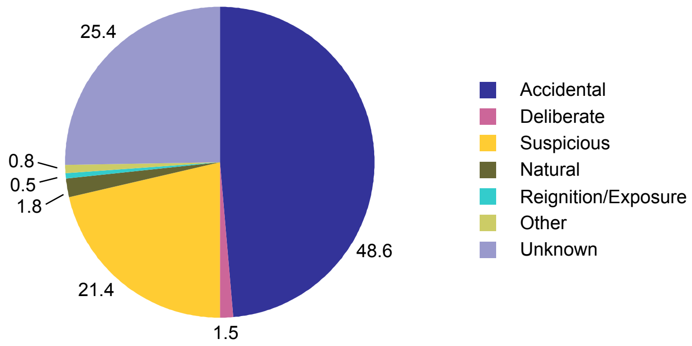
Figure 6: Cause of vegetation fires, by year[a]



a: 1997–98 data in this and all subsequent figures is incomplete

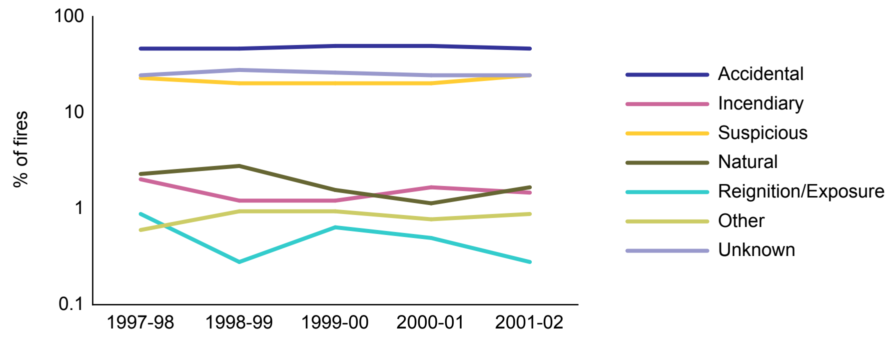
Source: MFB 1997–98 to 2001–02 [computer file]

Figure 7: Cause of fire (percent)



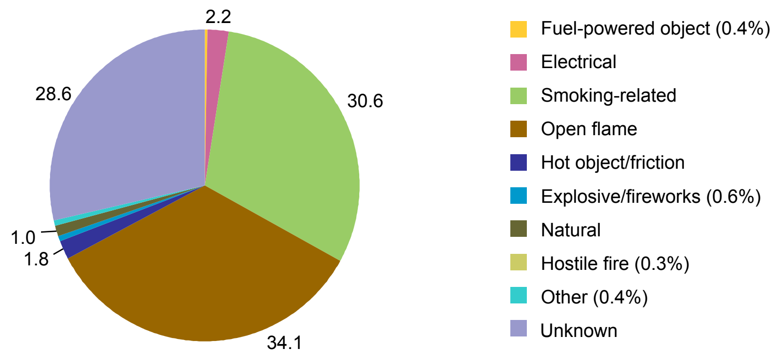
Source: MFB 1997–98 to 2001–02 [computer file]

Figure 8: Cause of fire, by year (percent)



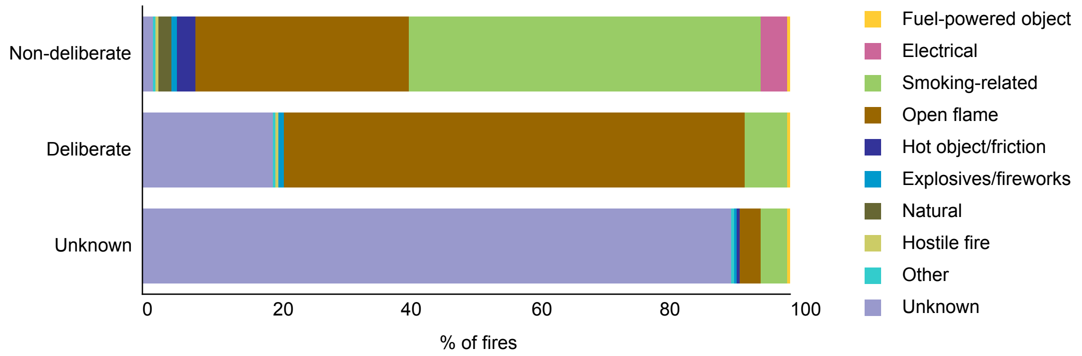
Source: MFB 1997–98 to 2001–02 [computer file]

Figure 9: Form of heat of ignition (summarised; percent)



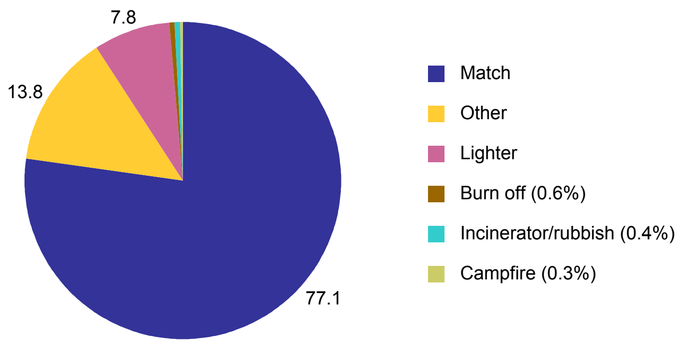
Source: MFB 1997–98 to 2001–02 [computer file]

Figure 10: Fire cause, by form of heat of ignition (percent)



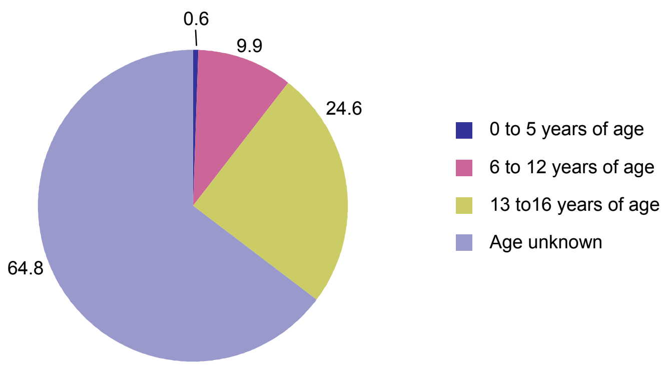
Source: MFB 1997–98 to 2001–02 [computer file]

Figure 11: Specific form of heat of ignition for fires involving an open flame or spark (percent)



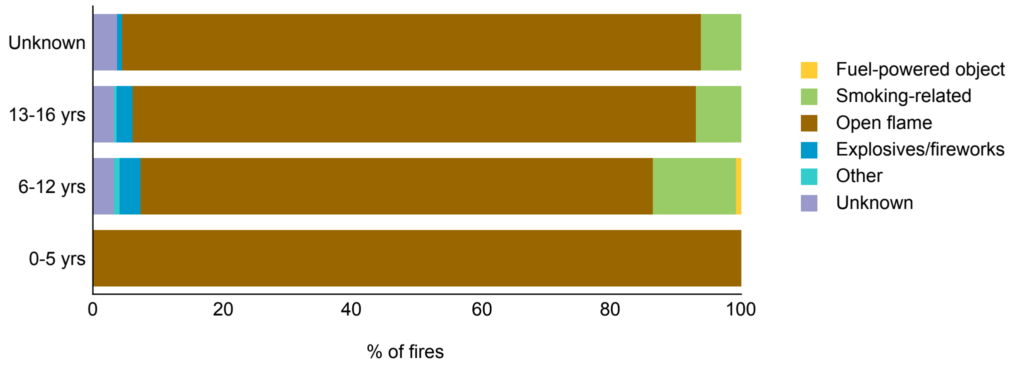
Source: MFB 1997–98 to 2001–02 [computer file]

Figure 12: Non-deliberate child fires, by age (percent)



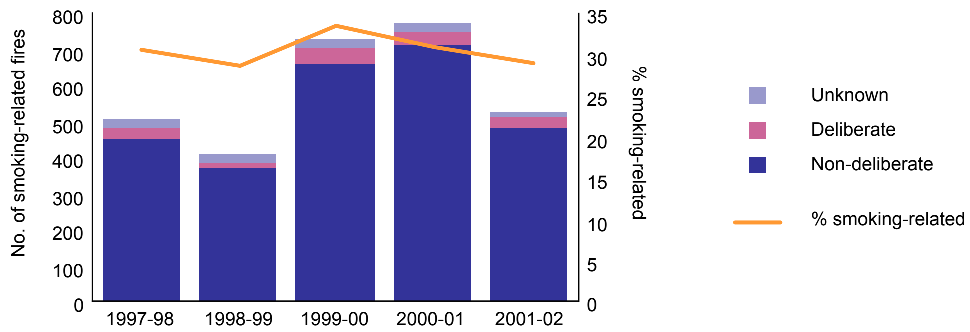
Source: MFB 1997–98 to 2001–02 [computer file]

Figure 13: Non-deliberate child fires, by age, and by form of heat of ignition (percent)



Source: MFB 1997–98 to 2001–02 [computer file]

Figure 14: Smoking-related vegetation fires, by year



Source: MFB 1997–98 to 2001–02 [computer file]

Location

The location of fires the MFB attended was analysed at a statistical subdivision (SSD) scale, with the distribution of fires also being examined relative to the population densities within individual postcodes, and by the type of complex or use of the property where a fire occurred.

Statistical subdivision

Most MFB-attended vegetation fires occurred in the northern and western portions of the city, within the Western Melbourne, Northern Middle Melbourne, Hume City, and Northern Outer Melbourne SSDs (Figure 15). However, no postcodes in the Melbourne metropolitan area recorded more than 100 vegetation fires per year. The highest number of vegetation fires was recorded for one postcode in the Hume City SSD (n=474 in five years). Three of the six postcodes recording the highest number of vegetation fires, and two of the top three, occurred in the neighbouring Western Melbourne SSD. The highest proportion of deliberate vegetation fires (incendiary and suspicious fires combined) occurred in the Hume City (30%) and Moreland City (25%) SSDs.

The MFB attended comparatively few vegetation fires in the Yarra Ranges Shire and Greater Dandenong City SSD, as these areas principally lie within CFA jurisdiction. Hence, the low rates of deliberate vegetation fires the MFB recorded in these areas are not likely to have been representative. However, other areas in eastern Melbourne, including Eastern Middle and Eastern Outer Melbourne SSD also recorded comparatively low percentages of deliberate vegetation fires (typically 15 to 17%), as did the Inner Melbourne SSD (12%).

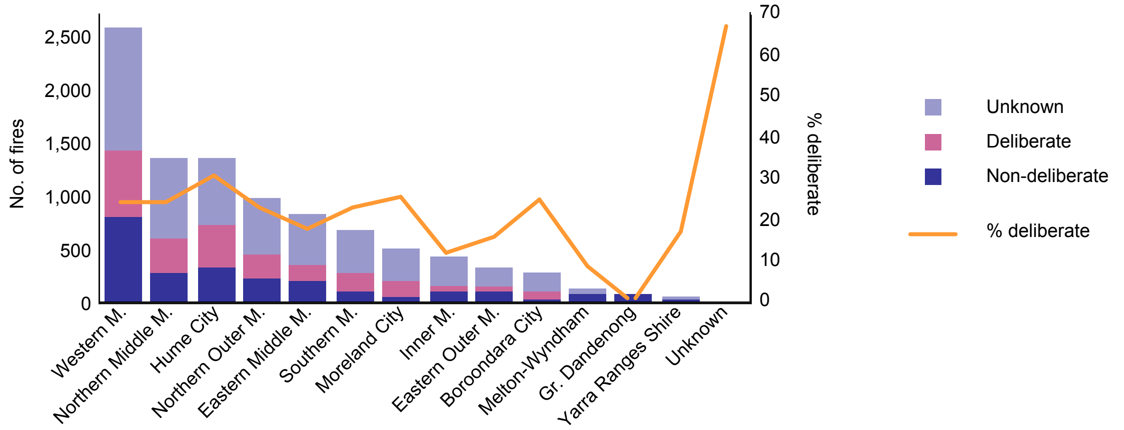
The proportion of deliberate vegetation fires was highly variable at a postcode level; deliberate causes accounted for 0 to 53 percent of vegetation fires in any postcode. The greatest heterogeneity was evident for postcodes with low total vegetation fire frequencies (fewer than 10 per year). At greater frequencies, where sampling errors were less likely to be of importance, there was a tendency for the proportion of deliberate vegetation fires in a postcode to increase with the total number of vegetation fires (Figure 16).

The greatest number of non-deliberate child fires occurred in the Hume City, Western Melbourne, Northern Outer Melbourne and Northern Middle Melbourne SSDs; that is, in areas with the highest number of vegetation fires generally (Figure 17). Between 27 and 31 percent of vegetation fires in the Northern Outer Melbourne, Hume City and Moreland City SSDs were classified non-deliberate fires lit by children. In contrast, only three percent of vegetation fires in the Inner and Southern Melbourne SSDs were non-deliberate child fires (Figure 17).

Overall, the number of non-deliberate child fires was significantly correlated with the total number of vegetation fires within SSDs ($r=.81$, significant at $p<0.001$), although some scatter was evident (Figure 18). Numbers of non-deliberate child vegetation fires, like vegetation fires generally, were heterogeneously distributed within each SSD, with a high proportion occurring within a small number of postcodes (Figure 19). The demographic structure of suburbs (such as age distribution) was likely to have played a significant role in the number of fires started by children.

The greatest number of smoking-related fires occurred in the Western Melbourne (SSD, followed by the Northern Melbourne and Eastern Middle Melbourne SSDs (Figure 20). There was significant correlation ($r=.94$; $p<.001$) between the number of smoking-related vegetation fires and the total number of vegetation fires within each SSD, although some dispersion in the data was evident at moderately high frequencies. Smoking-related fires accounted for the highest percentage of all vegetation fires in the Inner Melbourne (53%), Boroondara City (43%), and the Southern, Eastern Middle and Northern Middle Melbourne (37 to 40%) SSDs. That is, smoking-related fires accounted for a higher proportion of fires in more centrally located metropolitan areas (Figure 20).

Figure 15: Deliberate vegetation fires, by SSD[a, b]

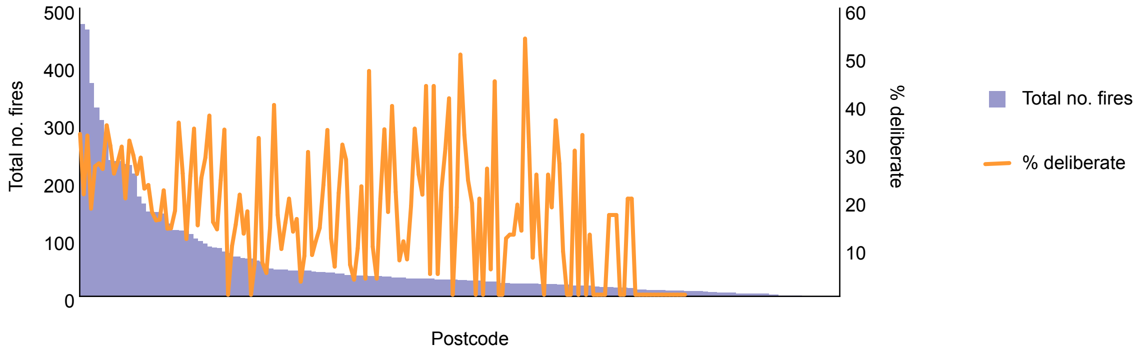


a: M. = Melbourne, Gr. = Greater

b: in many instances the CFA attended vegetation fires in the same SSD

Source: MFB 1997–98 to 2001–02 [computer file]

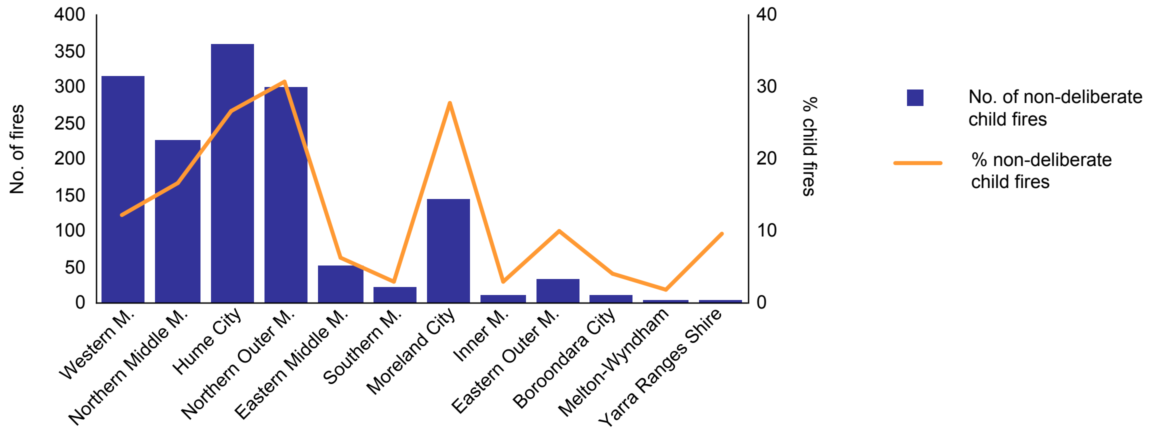
Figure 16: Total and deliberate fires in individual postcodes[a]



a: postcode identification has been removed to preserve the anonymity of those postcodes; fire agencies may source this information from the author

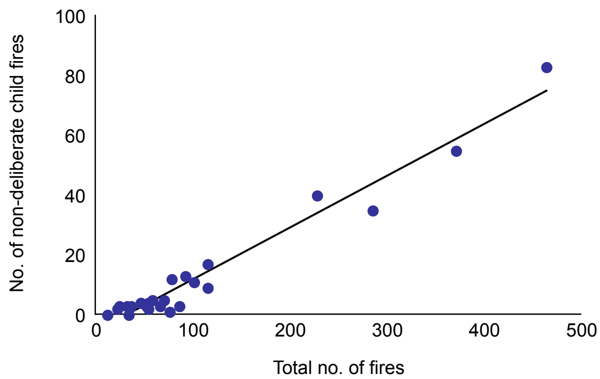
Source: MFB 1997–98 to 2001–02 [computer file]

Figure 17: Non-deliberate child fires, by SSD



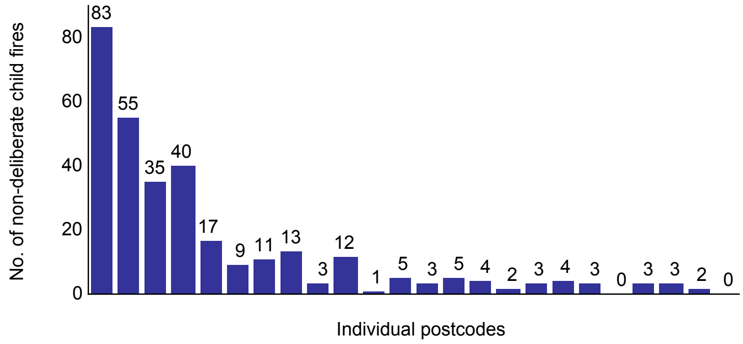
Source: MFB 1997–98 to 2001–02 [computer file]

Figure 18: Non-deliberate child fires and total fire numbers, by postcode (number)



Source: MFB 1997–98 to 2001–02 [computer file]

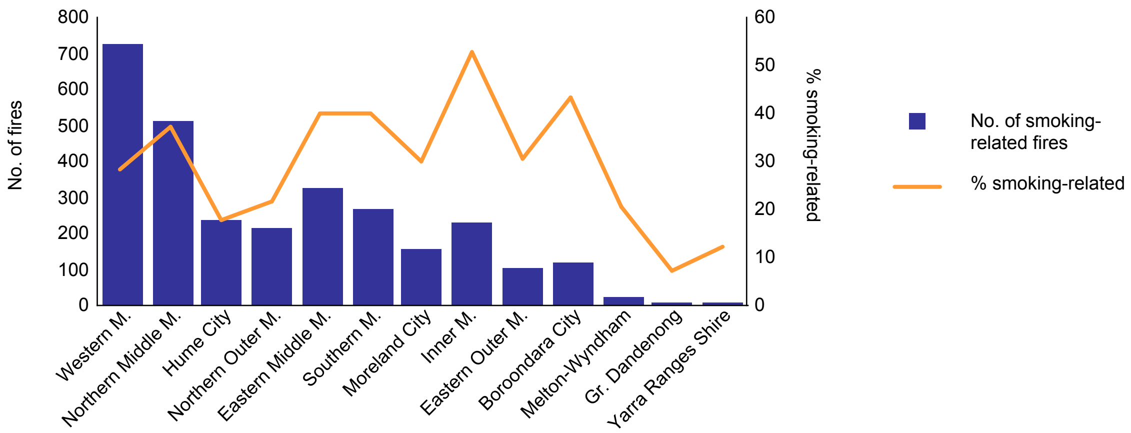
Figure 19: Non-deliberate child, by postcode[a] in the Western Melbourne postcode SSDs (number)



a: postcode identification has been removed to preserve the anonymity of those postcodes; fire agencies may source this information from the author

Source: MFB 1997–98 to 2001–02 [computer file]

Figure 20: Smoking-related vegetation fires, by Melbourne SSDs



Source: MFB 1997–98 to 2001–02 [computer file]

Population analysis

There was a broad tendency for the total number of vegetation fires to increase with increasing population ($r=.41$; $p<.001$), although considerable variability exists in detail (Figure 21). There are a number of possible reasons for this variability, including:

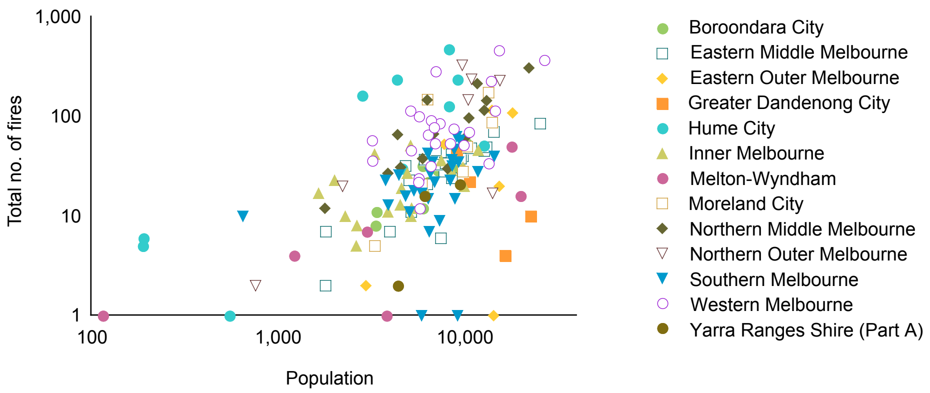
- genuine variations in the total number of vegetation fires
- the Victorian Country Fire Authority may have attended fires within the same postcode, consequently the data the MFB provided do not give an adequate overview for all postcodes, particularly in eastern and southern Melbourne and Melton–Wyndham SSDs
- some postcodes may have had a low residential population but were areas that received a higher influx of visitors from other regions.

All vegetation fires: Based on the MFB data only, postcodes in metropolitan Melbourne experienced between three and 100 vegetation fires per 10,000 people per year (Figure 22). The rate for the Melbourne metropolitan area was on the low side when compared with some other Australian state and territory metropolitan cities. The lowest observed rates of fires occurred in the eastern and southeast areas of the metropolitan area, including Eastern Outer Melbourne and Southern Melbourne SSDs. Low rates in the Greater Dandenong City SSD almost certainly reflected the low level of coverage the MFB provided in this area. The highest rates occurred in those SSDs that recorded the highest total number of vegetation fires, namely Western Melbourne, Northern Outer Melbourne and Hume City (Figure 22).

Deliberate vegetation fires: Between 0.2 and 38 deliberate vegetation fires per 10,000 people per year occurred in metropolitan Melbourne postcodes (based on MFB data only; see below for combined MFB and CFA analysis) during the observation period. Large fluctuations were evident for postcodes within SSDs, and broad differences were evident between postcodes from different SSDs. The lowest rates of deliberate fires per person generally occurred in those areas experiencing lower overall vegetation fire frequencies, namely, Inner Melbourne, Eastern Middle Melbourne, Eastern Outer Melbourne and Southern Melbourne SSDs (Figure 23). Insufficient data were available within the MFB database alone to determine rates of deliberate vegetation fires in most postcodes in the Greater Dandenong and Yarra Ranges Shire SSDs. Even considering population differences, the highest rates of deliberate vegetation fires occurred in the Hume, Western, Northern Outer Melbourne and to a lesser extent Northern Middle Melbourne SSDs; that is, in those areas that experienced the highest total and deliberate vegetation fire frequencies.

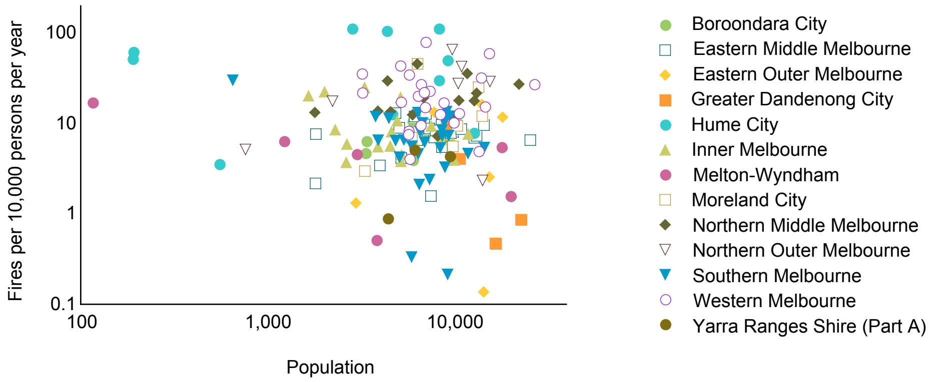
Smoking-related vegetation fires: One postcode recorded almost 30 smoking-related vegetation fires per year, 11 had 10 to 20, and 30 had five to 10. In contrast to both total and deliberate vegetation fires, there was comparatively little regional variation in the rate of smoking-related vegetation fires (Figure 24). Overall, individual postcodes recorded between 0.2 and 25 smoking-related vegetation fires per year: four postcodes had 20 to 25, 14 had 10 to 20, and 34 had five to 10 per 10,000 people.

Figure 21: Vegetation fires and population by postcode, for individual SSD (number)



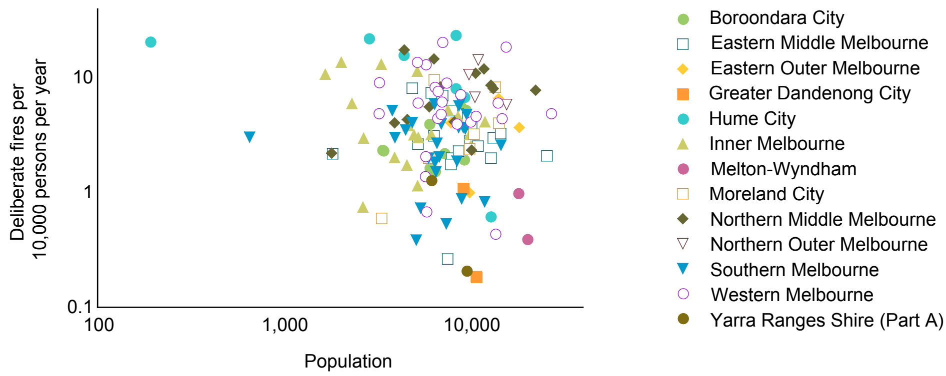
Source: MFB 1997–98 to 2001–02 [computer file]; ABS 2004. Population by post office area, 2001 [computer file]

Figure 22: Vegetation fires per 10,000 people year, for individual postcodes, by SSDs (number)



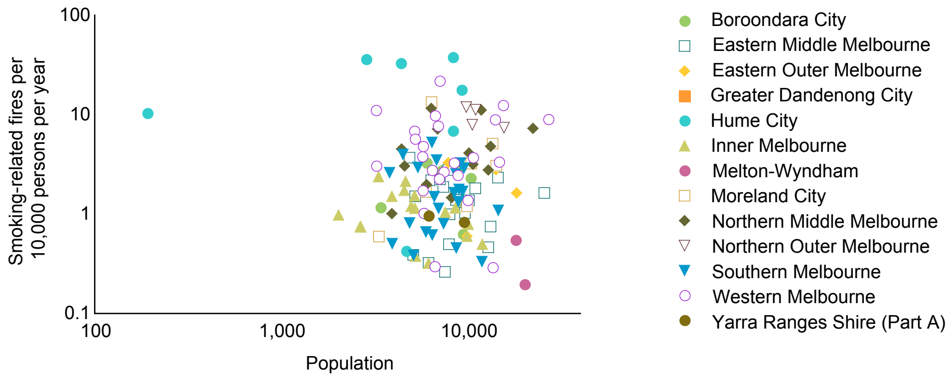
Source: MFB 1997–98 to 2001–02 [computer file]; ABS 2004. Population by post office area, 2001 [computer file]

Figure 23: Deliberate vegetation fires per 10,000 people, for individual postcodes, by SSD (number)



Source: MFB 1997–98 to 2001–02 [computer file]

Figure 24: Smoking-related vegetation fires, for individual postcodes, by SSD (number)



Source: MFB 1997–98 to 2001–02 [computer file]; ABS 2004. Population by post office area, 2001 [computer file]

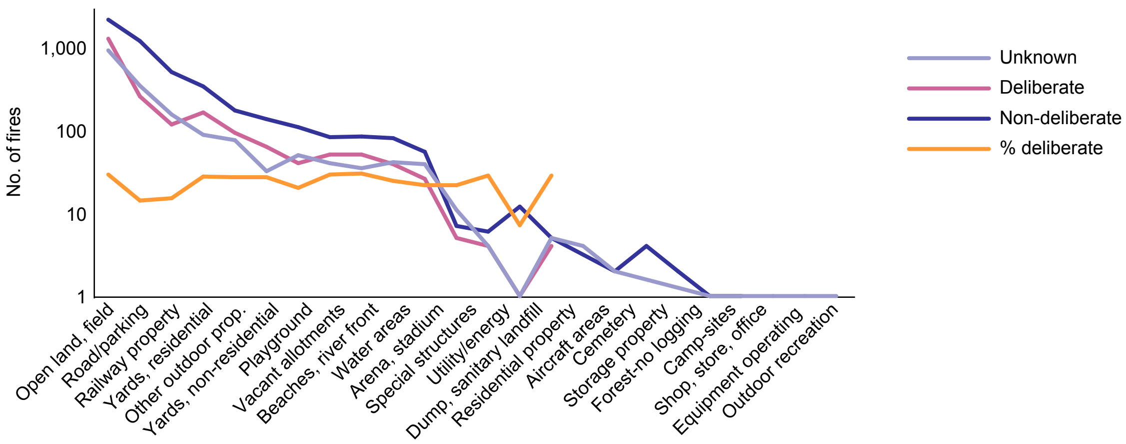
Property use/complex

The following analysis examines the property use for fires generally and type of complex (grouping based on principal property use; see glossary for definition) where non-deliberate child fires occurred. These location details derive from existing categories with AIRS variables of the same name.

Most vegetation fires in the Melbourne metropolitan area occurred on open land and fields (35%), roads/parking complexes (31%) and railway property (12%; Figure 25). This general distribution was evident irrespective of cause. The percentage of deliberate vegetation fires was comparatively uniform (25 to 30%) across most areas that experienced more than 10 vegetation fires in five years, although somewhat lower rates occurred for roads/parking lots and on railway property, owing to higher contributions from accidental causes.

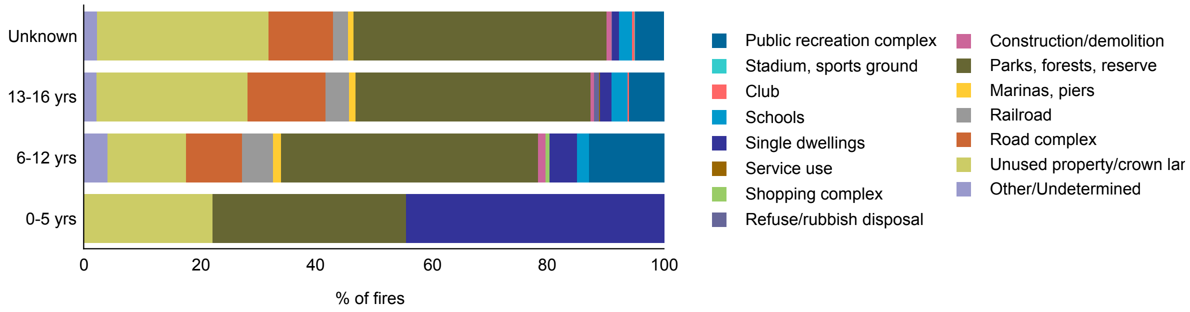
There was increasing complexity, with age, in the types of locations where children accidentally caused a vegetation fire. Notably, most fires lit by children in the 0 to 5 year age group occurred around homes (single dwellings), in parks, forests or reserves, and on unused property and Crown land (Figure 26). The proportions of vegetation fires lit at single dwellings decreased for older children. However, the proportion of non-deliberate child vegetation fires that occurred in parks, forests or reserves and on unused property and Crown land remained relatively stable. Six to 12 year olds in the Melbourne metropolitan district set a higher proportion of fires around public recreation complexes than did 13 to 16 year olds, but both groups lit more vegetation fires in that location than around a school. Unused property and Crown land featured more in fires lit by 13 to 16 year olds than for 6 to 12 year olds.

Figure 25: Property use, by cause



Source: MFB 1997–98 to 2001–02 [computer file]

Figure 26: Non-deliberate child fires, by age and, by complex[a] (percent)



a: other/unknown includes fires lit at the following complexes care facility (1), religious use (3), communication (1), judicial/archival (1), child day care (1), apartments (4), military (1), industrial/manufacture (1), and warehouse/storage (1)

Source: MFB 1997–98 to 2001–02 [computer file]

Timing

The timing of fires the MFB attended was examined by week of the year, day of the week, and time of the day.

Week of the year

Most vegetation fires in the Melbourne metropolitan area occurred between mid November and late March, with the greatest numbers occurring near Christmas (Figure 27). This general pattern was present for both non-deliberate and deliberate fires. However, the temporal distribution of vegetation fires varied between bushfire danger seasons.

Typically, the number of vegetation fires peaked in early summer (near Christmas–New Year) and subsequently decreased over the remainder of summer and early autumn. In contrast, an unusually high number of vegetation fires occurred during late summer and autumn in 2000–01 (Figure 28). The peak number was also slightly later in 1998–99.

Overall, non-deliberate child vegetation fires defined three peaks in activity (Figure 29); one coincident with Christmas–New Year, one at week five (coincident with the start of the school year), and another at roughly week 10 (principally in 2001). No significant differences were evident between the timing of fires attributed to children of different ages, although there was a large increase in fires coincident with the start of the new school year for 13 to 16 year olds.

Day of the week

Some 29 to 34 percent more incendiary and suspicious fires occurred on Saturdays or Sundays than on weekdays in metropolitan Melbourne, with marginally more fires occurring on Sundays than Saturdays (Figure 30). Approximately 10 percent more non-deliberate fires occurred on Saturdays than other weekdays.

Overall, children lit 10 percent more non-deliberate fires on Sunday and 22 percent more on Saturday than on other weekdays, but this relationship was not systematic. For example, the total number of non-deliberate child fires lit on Mondays was comparable to those lit on Sundays. The highest percentage of weekend fires occurred for the 13 to 16 year olds, with the number of fires on Sunday and Saturday being 20 and 37 percent greater than on the average weekday (Figure 31). However, this group was also associated with a high number of fires on Wednesdays and to a lesser extent Tuesdays.

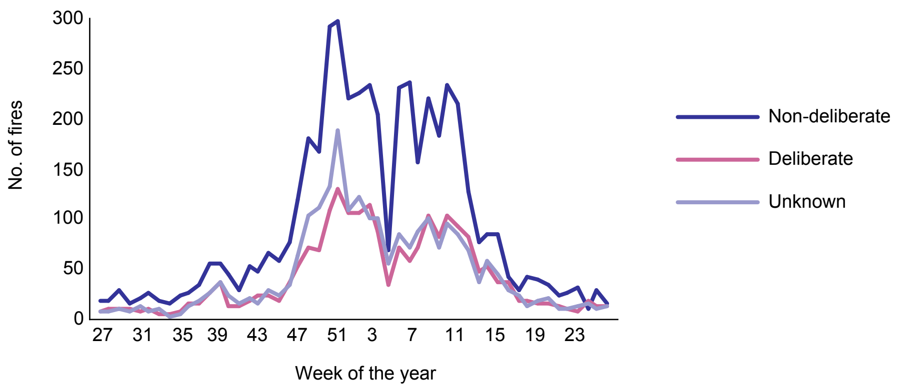
Time of day

The time at which the alarm was raised was available for approximately 60 percent of MFB-attended vegetation fires. Most vegetation fires occurred during daylight hours, but markedly different distributions were evident for non-deliberate and deliberate vegetation fires. The peak in accidental vegetation fires occurred between 4 and 5 pm (Figure 32), somewhat later than in other jurisdictions. The distribution of deliberate fires was also unique. The frequency of deliberate fires increased from late morning onwards, reaching a maximum at around 5 to 6 pm, somewhat later than some other metropolitan centres. Also in contrast with other jurisdictions, the number of deliberately lit fires remained elevated until midnight, only decreasing in the early hours of the morning. Almost 60 percent of deliberately lit vegetation fires in the Melbourne metropolitan area occurred after 6 pm and before 6 am. The high proportion of fires lit between 6 pm and midnight, in particular, may relate to extended daylight during the summer months, including daylight saving.

A high number of vegetation fires in the Melbourne metropolitan area occurred between 6 pm and 6 am irrespective of the night of the week (Figure 33). The only notable differences between weekdays and weekends pertained to a greater number of vegetation fires between midnight and 4 am on Saturday and Sunday mornings, a finding consistent with that observed in most other metropolitan areas. Extended daylight hours may enable people to be outside in their neighbourhood to later hours, irrespective of the day of the week, thus reducing the distinction between weekends and weekdays. Alternatively, they may simply reflect social patterns that are specific to Melbourne and unrelated to such physical parameters.

The available data imply some differences in the timing of vegetation fires lit by children based on age (Figure 34), although some caution is needed in this interpretation due to the low proportion of cases where the age of the child was known. The vast majority of vegetation fires lit by children aged six to 12 occurred between midday and 10 pm, during daylight hours during summer, with the greatest number occurring between 4 and 6 pm. The number of vegetation fires occurring between 10 pm and 6 am was comparatively low. In contrast, the pattern for 13 to 16 year olds was remarkably similar to that for deliberate vegetation fires in general – fire numbers increased slowly from midday, reaching a maximum at roughly 6 pm, plateaued until midnight, and subsequently decreased. About 65 percent of all vegetation fires lit by 13 to 16 year olds occurred between 6 pm and 6 am, again similar to the general pattern. However, only 11 percent occurred between midnight and 6 am.

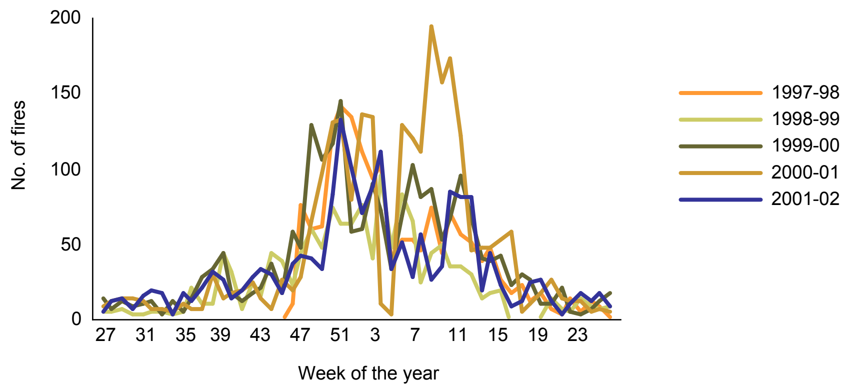
Figure 27: Week[a] of the year, by fire cause (number)



a: Week 1 = first week of January

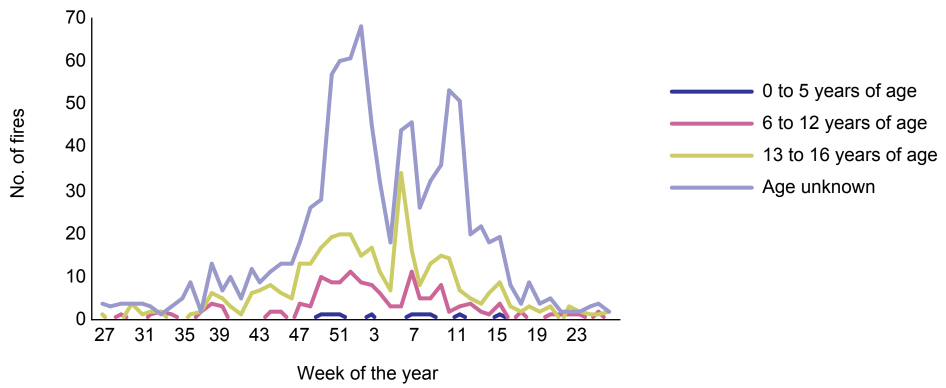
Source: MFB 1997–98 to 2001–02 [computer file]

Figure 28: All vegetation fires, by week of the year, for each year (number)



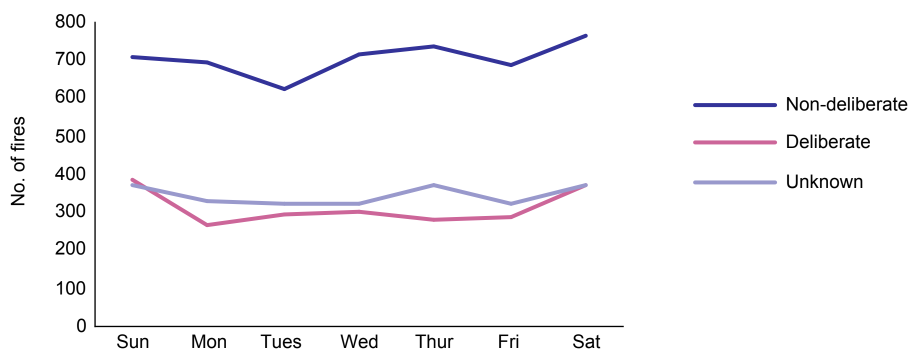
Source: MFB 1997–98 to 2001–02 [computer file]

Figure 29: Non-deliberate child fires lit, by week of the year, for individual age groups (number)



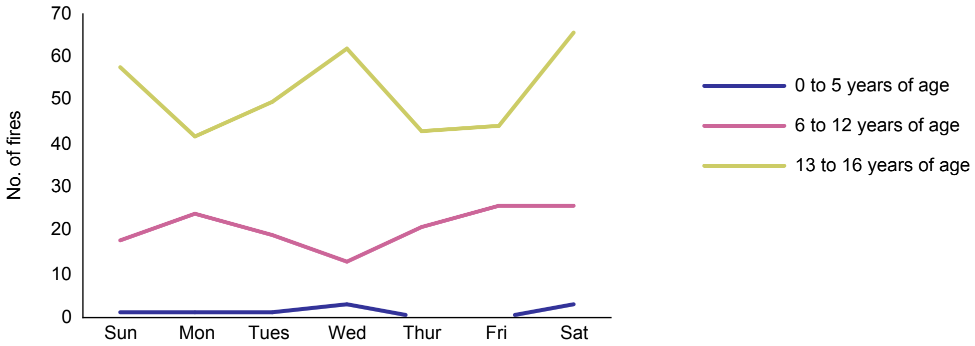
Source: MFB 1997–98 to 2001–02 [computer file]

Figure 30: Day of occurrence, by cause (number)



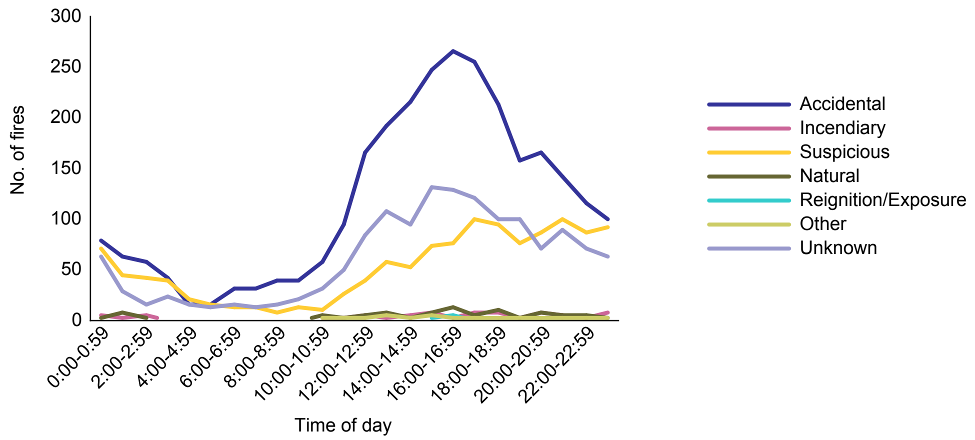
Source: MFB 1997–98 to 2001–02 [computer file]

Figure 31: Day of occurrence of non-deliberate child fires (number)



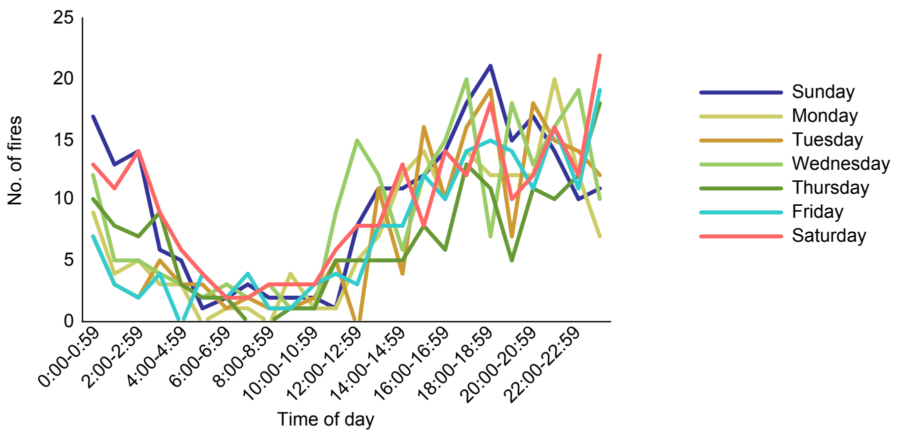
Source: MFB 1997–98 to 2001–02 [computer file]

Figure 32: Time of day of alarm, by cause (number)



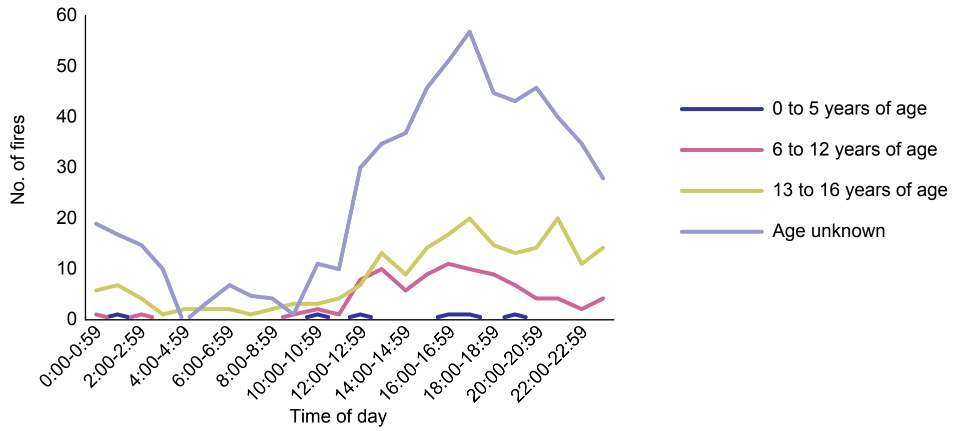
Source: MFB 1997–98 to 2001–02 [computer file]

Figure 33: Time of day of deliberate fires, each day (number)



Source: MFB 1997–98 to 2001–02 [computer file]

Figure 34: Time of the day of non-deliberate child fires, by age group (number)



Source: MFB 1997–98 to 2001–02 [computer file]

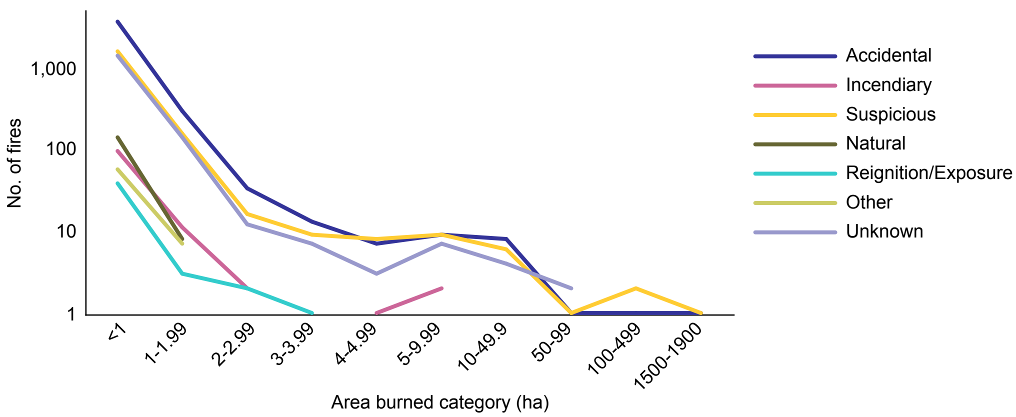
Area burned

Overall, the number of vegetation fires declined sharply with increasing fire size, irrespective of cause (Figure 35; note that one fire listed as having burned 9,999 ha in inner Melbourne was considered to be in error and was deleted in this analysis). Ninety percent of fires the MFB attended were less than one hectare, and 98 percent were less than two hectares. The two largest fires were a fire of accidental causes that burned 1,945 ha in Northern Outer Melbourne in 2000–01 and a suspicious fire that burned 1,950 ha in Northern Middle Melbourne during the same year.

Approximately 5,800 ha of land was burned in the Melbourne metropolitan area in the five-year interval from 1997–98 to 2001–02. The two large vegetation fires outlined above dominated this total area. Incendiary and suspicious vegetation fires were responsible for 45 percent of the total area burned (Figure 36). A further 46 percent burned in accidental vegetation fires. Natural fires accounted for just 0.2 percent of the total area burned in metropolitan Melbourne. These trends are clearly different from those in regional Victoria, where large natural and accidental fires accounted for a high proportion of the large areas burned. Smoking-related fires burned 333 ha (6%) of the total area in fires the MFB attended.

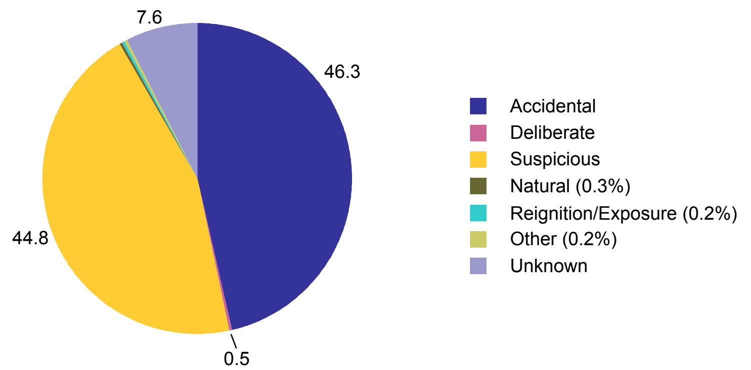
The overwhelming majority of the area burned was burned in 2000–01 (Figure 37). The greatest total area burned was in Melbourne's north, principally due to the two large fires.

Figure 35: Area burned (ha) categories, by fire cause (number)



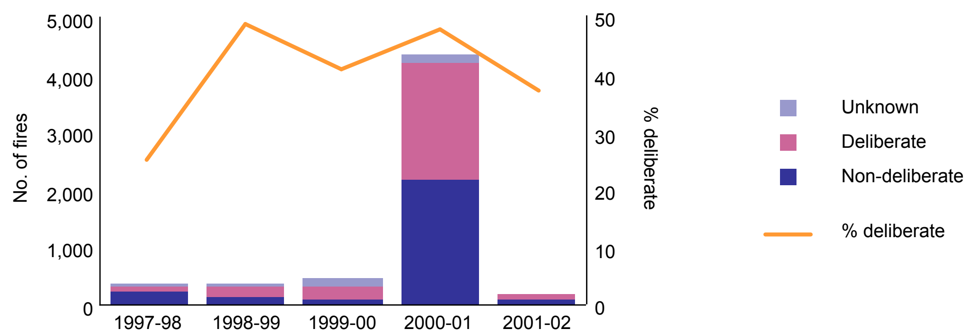
Source: MFB 1997–98 to 2001–02 [computer file]

Figure 36: Total area burned by cause (percent)



Source: MFB 1997–98 to 2001–02 [computer file]

Figure 37: Area burned, by cause (ha) and area burned by deliberate vegetation fires (percent), 1997–98 to 2001–02



Source: MFB 1997–98 to 2001–02 [computer file]

Type of incident

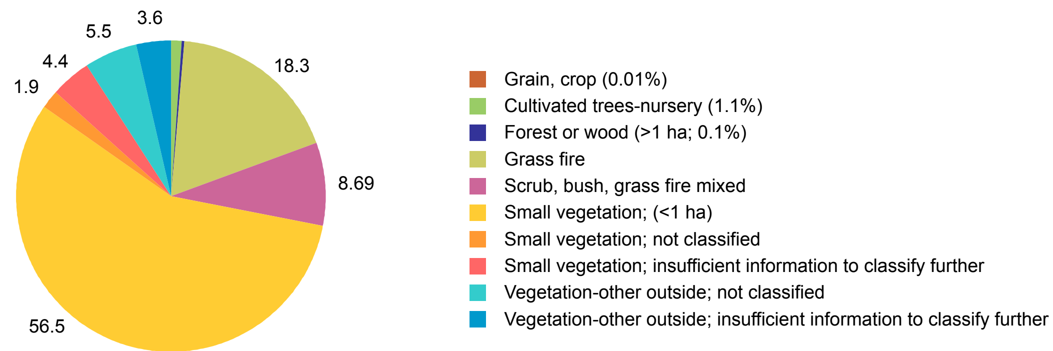
Almost two-thirds (62.8%) of all vegetation fires were classified as small vegetation fires, with 56.5 percent categorised as ‘small vegetation fire (less than one ha)’ (Figure 38). A further 1.9 percent and 4.4 percent, respectively, were classified as ‘small vegetation fire; not classified’ and ‘small vegetation fires; insufficient information to classify further’. Grassfires comprised 18.3 percent of all vegetation fires, with scrub/bush/grass mixtures accounting for a further 8.6 percent, and forest or woods (greater than one ha) 0.1 percent.

The proportion of each incident type varied slightly across Melbourne SSDs (Figure 39). Small vegetation fires (the three categories combined) formed the lowest percentage (53 to 57%) of vegetation fires in Boroondara City, Eastern Middle Melbourne, Melton–Wyndham, Southern Melbourne, Moreland City and Hume City SSDs. The highest percentage of small vegetation fires (67 to 68%) occurred in Northern Middle Melbourne, Yarra Ranges and Western Melbourne SSDs. Approximately 33 and 27 percent of vegetation fires in Melton–Wyndham and Hume City were grassfires, respectively. In contrast, grassfires comprised just six to seven percent of fires in the Yarra Ranges and Eastern Outer Melbourne. Despite these minor variations between SSDs, there was little evidence to suggest that vegetation fires in one part of the city were fundamentally different in character from those observed elsewhere.

Overall, the percentage of deliberate causes was similar (20 to 26%) across most incident types (Figure 40). The exceptions were cultivated tree/nursery (n = 109) and grain/crop fires (n=1), which had higher and lower rates of deliberate fires, respectively. Neither could be regarded as a typical urban vegetation fire. The results showed that there was not a specific type of incident associated with deliberate fires; although a greater number of fires in urban areas were small vegetation fires there was not a higher probability that those fires were deliberately lit. An understanding of the inherent type of vegetation present in each area is needed to assess if it was merely a question of access that governed the proportion of small vegetation fires as compared to grass or forest fires.

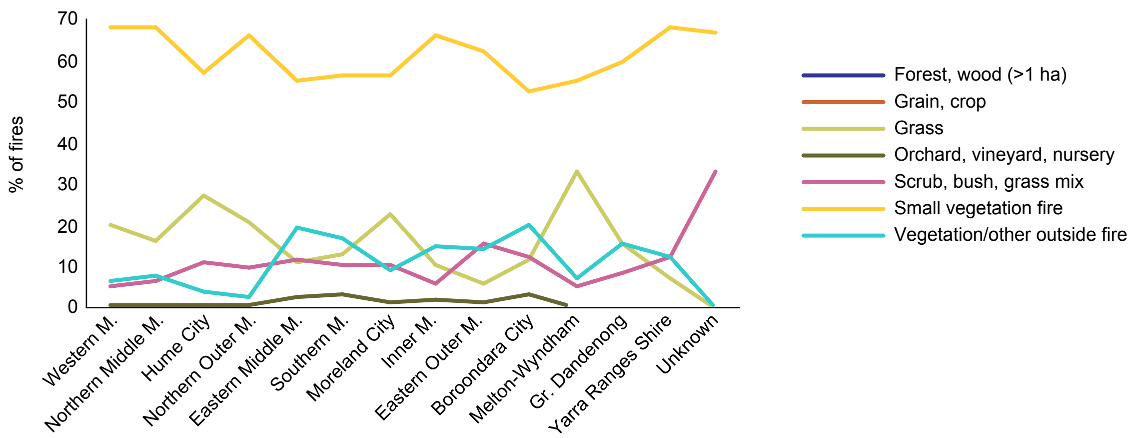
Based on the data provided, it was impossible to estimate the percentage of vegetation fires that were, or had the potential to manifest into, bushfires. However, there was significant positive correlation between the combined number of forest/wood, scrub/bush/grass mixed and grass fires (that is, vegetation fires that could be most reasonably constitute a bushfire) and the total number of vegetation fires ($r=.96$; $p<.01$; Figure 41). Even if most grass fires in the metropolitan area were unlikely to be bushfires, it was evident that the number of forest/wood and scrub/bush/grass fires combined, also increased with an increasing number of vegetation fires, although the relationship is better described by a second order polynomial expression ($y = -3E-05x2 + 0.1332x - 3.095$; $r = 0.958$) than a linear function ($r = .88$; $p < .001$). The results imply that bushfires were likely to have been most frequent in areas characterised by the highest number of vegetation fires.

Figure 38: Incident types (percent)



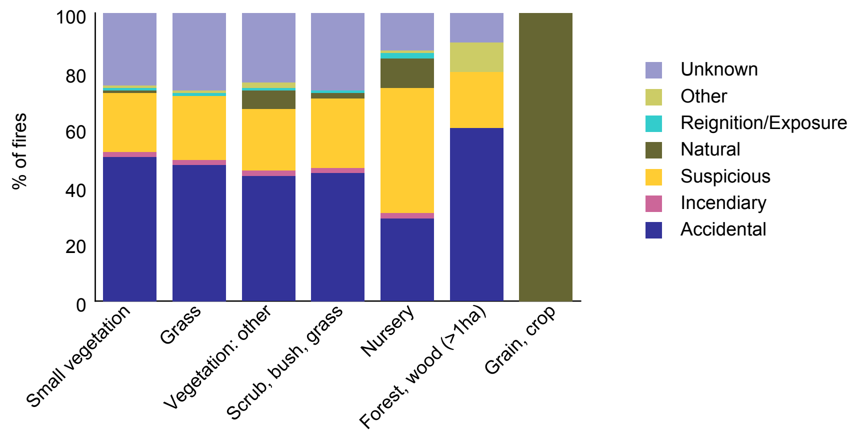
Source: MFB 1997–98 to 2001–02 [computer file]

Figure 39: Incident type by SSD (percent)



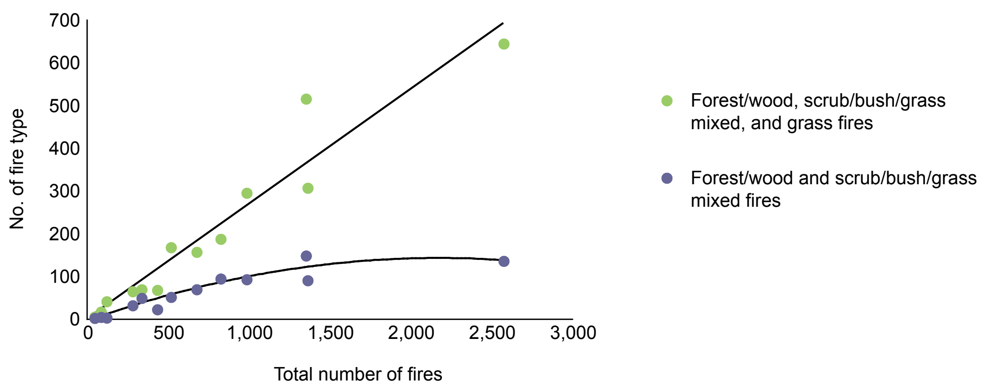
Source: MFB 1997–98 to 2001–02 [computer file]

Figure 40: Incident type by cause (percent)



Source: MFB 1997–98 to 2001–02 [computer file]

Figure 41: Relationship between incident type and number of vegetation fires (number)



Source: MFB 1997–98 to 2001–02 [computer file]

Fire danger rating

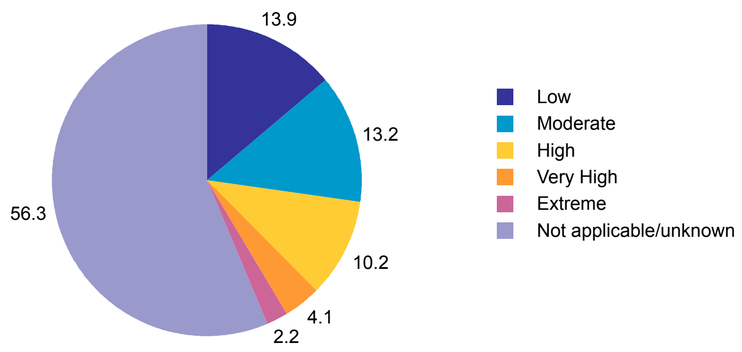
Fire danger rating relates to the likelihood of a wildfire developing, at a particular place, at a particular point in time. The MFB recorded the rating on the day each fire occurred in metropolitan Melbourne in 44 percent of cases (Figure 42). Overall, the percentage of vegetation fires assigned to each category decreased with increased fire danger (Figure 42); that is, fewer fires occurred under conditions of very high and extreme fire danger.

Differences were evident in the distribution of non-deliberate and deliberate vegetation fires between the low to extreme categories (Figure 43). The highest frequency of incendiary and suspicious fires was on moderate fire danger days and decreased with increasing fire danger weather. Overall, the frequencies of all vegetation fires decreased with increasing fire danger, but those that were deliberately lit decreased proportionately with increasing fire danger. They constituted 30 percent of vegetation fires occurring in moderate conditions but less than 20 percent occurring under extreme conditions. The proportion of vegetation fires resulting from an open flame (a high proportion of which were deliberate) decreased as the fire danger increased (Figure 44). Conversely, smoking-related fires made up a higher proportion of fires as the fire danger rating increased.

Although cases where the fire danger rating was documented varied (% known, Figure 45), the proportion of low versus moderate, high, very high and extreme fire danger rating was remarkably uniform across metropolitan Melbourne SSDs. The notable exception was the Melton–Wyndham SSD, where a higher proportion of vegetation fires occurred on high to extreme fire danger days. There was a trend for vegetation fires in the Southern Melbourne, Greater Dandenong City and Yarra Ranges Shire to occur during lower fire danger conditions. The MFB attended fewer fires in the Melton–Wyndham, Greater Dandenong and Yarra Ranges SSD, however, and combined MFB and CFA data are required to assess the accuracy of such trends.

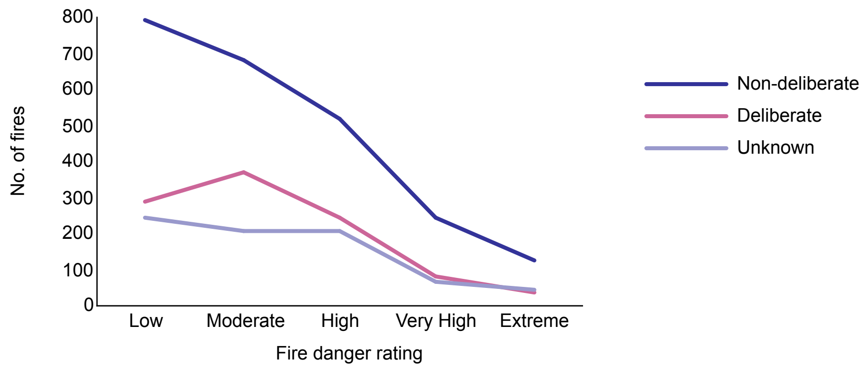
There was a close relationship between the location of deliberate vegetation fires on adverse fire danger days and their location generally. Notably, 84 percent of deliberate vegetation fires on very high fire danger days and 88 percent of deliberate fires on extreme fire danger days occurred in the four SSDs that recorded high numbers of deliberate vegetation fires generally; namely Western Melbourne, Northern Middle Melbourne, Hume City and Northern Outer Melbourne (Figure 46) and between 74 and 82 percent of deliberate vegetation fires during low to high fire danger conditions occurred in these SSDs.

Figure 42: Fires by fire danger rating (percent)



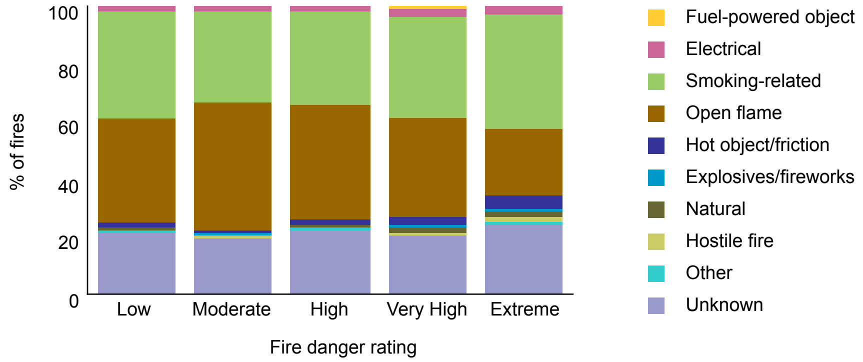
Source: MFB 1997–98 to 2001–02 [computer file]

Figure 43: Fires by fire danger rating (number)



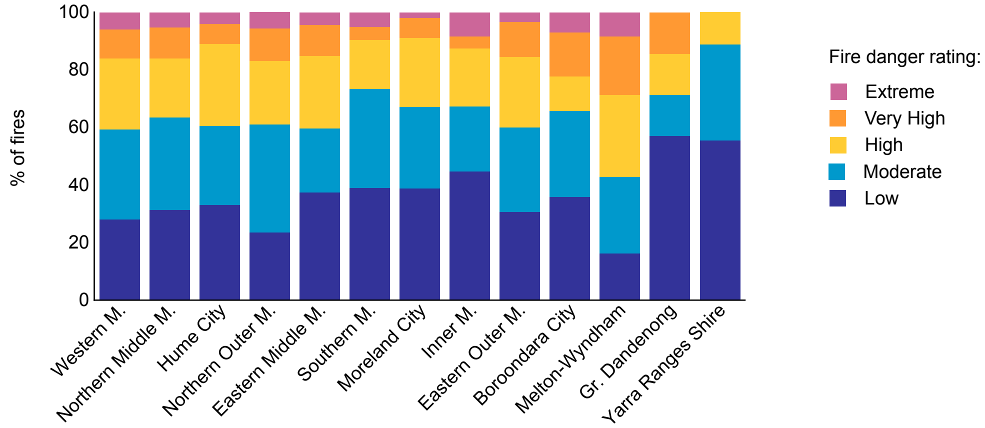
Source: MFB 1997–98 to 2001–02 [computer file]

Figure 44: Fire danger category by form of heat of ignition (percent)



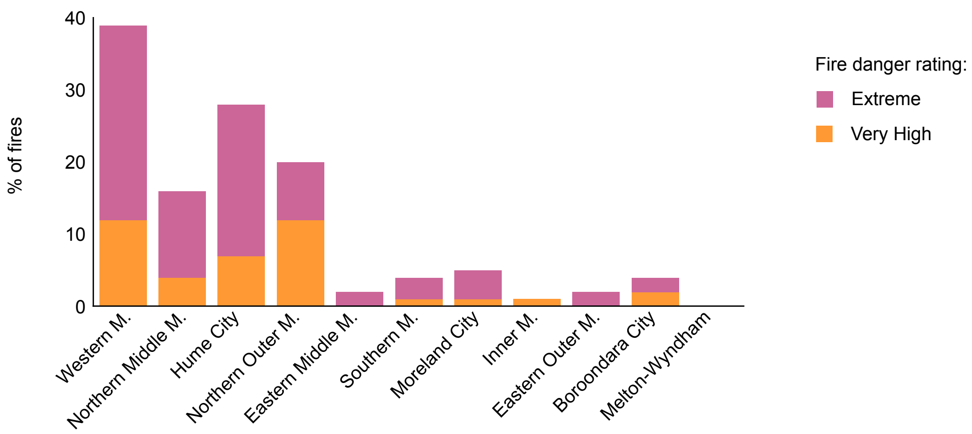
Source: MFB 1997–98 to 2001–02 [computer file]

Figure 45: Fire danger rating, by metropolitan Melbourne SSD (percent)



Source: MFB 1997–98 to 2001–02 [computer file]

Figure 46: Deliberate vegetation fires under very high and extreme fire danger ratings, by SSD[a] (number)



a: SSDs are arranged in order of decreasing total fire frequency

Source: MFB 1997–98 to 2001–02 [computer file]

Country Fire Authority

Background information about the CFA dataset and its analysis

Important information about the Victorian Country Fire Authority dataset and the methodology employed to analyse it is outlined below:

- The data were sourced from the Victorian Country Fire Authority (CFA).
- The database used AIRS classification codes.
- The dataset only included vegetation fires (AIRS wildfires = Type of Incident code 160 to 179).
- The data included vegetation fires from 1999–2000 to 2003–04.
- Cause defined was based on the ignition factor variable.
- Deliberate vegetation fires were all vegetation fires classified as incendiary (AIRS ignition factor code = 110 or 120) or suspicious (AIRS ignition factor code = 210 or 220). It is important to recognise that:

  > the CFA does not use the term 'deliberate' in its data recording but uses the terms 'suspicious' and 'incendiary' in Ignition Factor (E5), or 'malicious activity' in Activity in Ignition Area (E3). 'Deliberate' is taken to have other interpretations, for example, when used by Police that cannot be assumed by fire investigators when recording Ignition Factor. The term is used in this report to simplify the analysis and is not intended to reflect CFA conclusions about the cause of fires (CFA, pers. com. 2007).

- Natural vegetation fires were defined on the basis of ignition factor codes 800 to 890, which included any natural condition or event: high wind (41.6%), lightning (46.2%), high water (including flood; 0.2%), and any other natural condition (NC/IO; 12.0%).
- Information on form of heat of ignition was not supplied.
- Smoking-related vegetation fires were classified on the basis of:
  Ignition Factor = Abandoned, discarded material (Code = 310); hence all smoking-related fires were classified accidental in this analysis.
- All vegetation fires attributed to children and discussed in the text were classified accidental in origin; deliberate vegetation fires started by children were classified as incendiary or possibly suspicious and hence could not be identified in this analysis.
- The data included information on 'type of incident'.
- Definition of regions was based on tourism regions defined by the Australian Bureau of Statistics (2005b). Assignation to tourism region was made from the postcode (not provided) that was derived from the suburb name (provided). There was not an exact concordance between the postcode and tourism regions. The ABS defines tourism regions based on smaller statistical areas. Hence, ABS tourism regions potentially crosscut suburbs and postcodes. In this study, assignation was based on the highest levels of concordance between postcodes and tourism regions; there was not an exact correspondence between tourism regions used in this analysis and ABS tourism regions.
- Statistical local areas (SLA) were defined using the ABS Postal Area to Statistical Local Area Concordance (ABS 2001b) based on the highest levels of concordance. Statistical subdivisions (SSD) were generated from these SLAs using the ABS standard geographical classification (ABS 2001a). Again, there was not an exact correspondence between SLAs and SSDs used here and ABS SLAs and SSDs.
- Area burned data were included.
- Information was available about the status of fire restrictions but not the fire danger index.

For more detail about these methodologies see the methodology chapter.

Overview

Salient features of the CFA analysis can be summarised as:

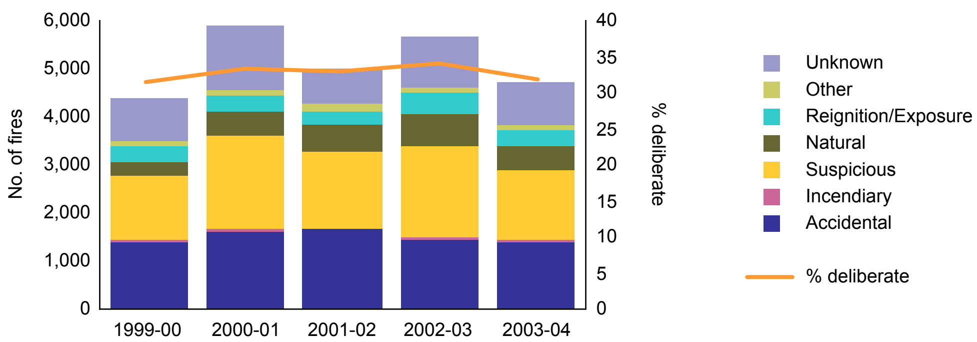
- The CFA attended 25,693 vegetation fires between 1999–2000 and 2003–04, on average, accounting for approximately two-thirds of all vegetation fires attended in Victoria each year. The number of vegetation fires remained relatively stable over the observation period, varying from 4,382 in 1999–2000 to 5,890 in 2000–01, with an average of 5,139 (sd=566; Figure 47). Although high fire frequencies occurred in 2002–03, they were marginally lower than in 2000–01.
- The fires occurred in a range of environments from the outer suburbs of metropolitan Melbourne, in and around major regional centres, to rural and remote locations. The CFA also helps the DSE fight fires on public lands; so many fires may be duplicated across these two agencies.
- The type of vegetation fire incidents attended varied from small vegetation fires in urban environments to large fires: 31.5 percent of incidents were small vegetation fires, 46.1 percent were grass fires, 8.9 percent were scrub/bush/mixed grass fires, 11.5 percent other vegetation and other outside fires (not classified or insufficient information to classify further), and 1.8 percent were forest or wood fires (greater than one ha).
- A total of 1,206,627 ha was burned in fires the CFA attended between 1999–2000 and 2003–04; of this, only 1.4 percent was by deliberate fires.
- Deliberate fires made up 32.9 percent of vegetation fires (40.5 percent of known causes), but were responsible for only 1.4 percent of the total area burned.

Cause

Incendiary causes were responsible for just 0.5 percent of vegetation fires, but a further 32.4 percent were suspicious in origin (Figure 48). Approximately one-third of all vegetation fires the CFA attended were deemed deliberate (incendiary and suspicious combined). A further 29 percent resulted from accidental causes, 10 percent were natural fires and 6.8 percent were from reignition or exposure. The cause of ignition in 19 percent of fires was unknown. Where cause was assigned, deliberate causes accounted for 40.5 percent of cases.

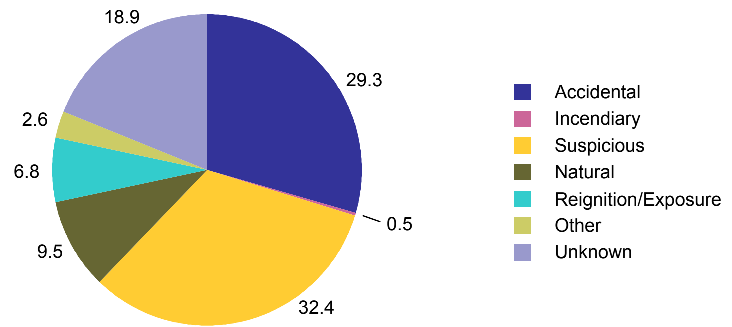
The number of deliberate vegetation fires ranged from 1,378 in 1999–2000 to 2,687 in 2002–03 (Figure 47). However, the proportion of deliberate fires remained stable during the five-year interval, varying between 31.4 percent in 1999–2000 and 34.3 percent in 2002–03 (Figure 47). The highest number of natural vegetation fires occurred in 2002–03 (n=643), followed by 2000–01 (n=515) and 2001–02 (n=508).

Figure 47: Vegetation fires by cause (number), and deliberate vegetation fires (percent)



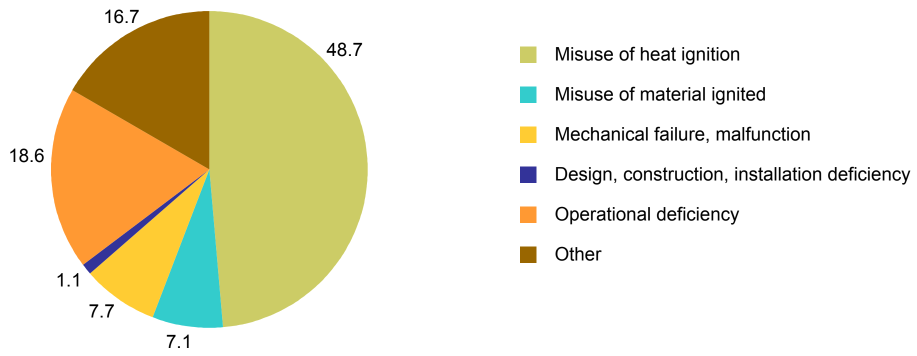
Source: CFA 1999–2000 to 2003–04 [computer file]

Figure 48: Cause of vegetation fires (percent)



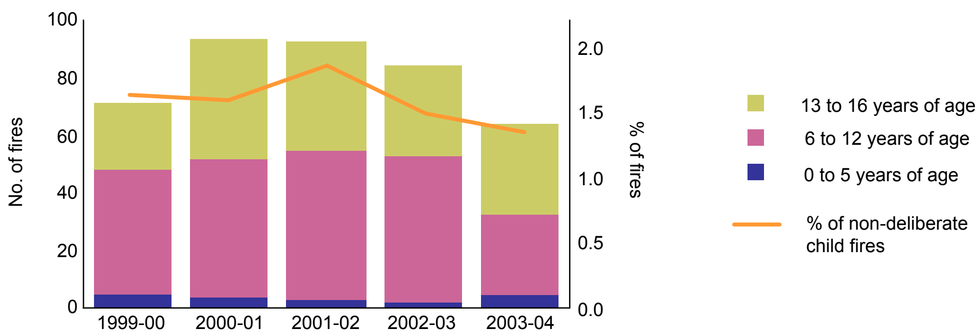
Source: CFA 1999–2000 to 2003–04 [computer file]

Figure 49: Accidental fires by ignition factor (percent)



Source: CFA 1999–2000 to 2003–04 [computer file]

Figure 50: Non-deliberate child fires, by age group, annually



Source: CFA 1999–2000 to 2003–04 [computer file]

Specific ignition factors

Ignition factor: As the form of heat of ignition was not available, the following analysis can only be conducted on the ignition factor variable; it is therefore limited to non-deliberate fires.

Almost half the accidental vegetation fires resulted from misuse of heat of ignition (Figure 49). Inadequate control of an open fire accounted for 60 percent (n=2,259); abandoned or discarded materials, 17 percent; children, 11 percent; and cutting and welding, six percent where the ignition factor was listed as misuse of heat of ignition.

Nineteen percent of accidental vegetation fires resulted from an operational deficiency. Of these, leaving a fire unattended accounted for half; spontaneous heating, 12 percent; and improper start-up-shutdown, 11 percent. Vegetation fires classified as 'Other' (in Figure 49) resulted exclusively from vehicles (AIRS code = 960). Vehicles (n=1,259) were the second most significant ignition factor, after inadequate control of open fire, in accidental fires; these were followed by leaving a fire unattended (n=698), and abandoned and discarded materials (n=639; 2.5% of all vegetation fires).

Natural fires may arise from a number of natural conditions or events (see methodology chapter). Only 46 percent of natural fires were indicated to be the result of lightning. Approximately 1,014 fires (42% of natural fires) were attributed to high wind. It is unclear to what extent this genuinely reflected 'natural' ignitions (for example, high winds responsible for power lines clashing) or if wind was an instigating factor in the escape of human-caused, fires such as burn offs (see below). If there was a high proportion of the latter, this analysis may have overestimated the actual proportion of natural fires and underestimated the proportion of accidental ignitions or other causes.

More than 98 percent (n=1717) of fires within the reignition/exposure category resulted from the re-kindling of previous fires; the remainder were the result of attached or separate exposure.

Fires started by children: The CFA attributed 406 vegetation fires to children less than 16 years playing (that is, non-deliberate fires) – only 1.6 percent of all fires the CFA attended in the five-year period. The number of deliberate fires started by children was unknown.

The highest number of non-deliberate child vegetation fires occurred in 2000–01 (n=94) and 2001–02 (n=93; Figure 50). In 2001–02, non-deliberate child fires comprised 1.9 percent of all fires, but both the number and proportion of non-deliberate fires decreased in the subsequent two years, with only 64 incidents (1.4% of all vegetation fires) in 2003–04.

Six to 12 year olds started 54 percent of non-deliberate child fires and children aged between 13 and 16 years lit another 41 percent. Only five percent of non-deliberate child fires resulted from fire-play by children five years or younger.

Activity in the area: The CFA was one of few agencies that recorded information about the 'activity in the area'. The following analysis provides a valuable perspective on factors that led to fires occurring, but also highlights fundamentally difficulties in accurately recording and interpreting causal information.

Sixteen percent of vegetation fires were related to transportation (not off-road). This was the largest 'activity in the area' category (Figure 51). Commercial activities were associated with 14.3 percent of vegetation fires. The overwhelming majority of these were land-based practices such as agriculture. Burning rubbish accounted for 9.4 percent of fires; most of these resulted from the burning of waste heaps, rubbish and garden litter ('rubbish–waste, rubbish' in Figure 51). Recreational activities accounted for 2.2 percent, the majority from activities like camping and picnicking (including home barbecues) rather than hunting, fishing, shooting, hiking and sightseeing. Fuel reduction burning was associated with 5.3 percent of vegetation fires, with an additional 1.9 percent linked to 'land clearing, heaps or windrows etc.'. 'No activity/not applicable' accounted for a further 16 percent, and activity was not recorded in 13 percent of cases.

There is some relationship between the causal classification used elsewhere in this analysis (defined on the ignition factor alone), and the type of activity in the area, but no one-to-one correspondence. This is obvious from the fact that 'malicious activity' accounted for 16.9 percent of all vegetation fires (Figure 51), but incendiary and suspicious causes ignition factor codes were assigned in 32.9 percent of cases (Figure 48). Incendiary and suspicious fires can potentially be associated with many different activities. Apart from incendiary and deliberate fires, malicious activity was most frequently associated with transportation, no activity/not applicable and activities not classified (Figure 52), accounting for 53, 17 and 32 percent of fires within these categories respectively. Although suspicious and, to a much lesser extent, incendiary fires accounted for just 5.9 percent of commercial land based activity fires, there were 202 such instances and this was the leading source of suspicious fires outside the categories outlined above. Deliberate fires also accounted for 50 percent of commercial water-based, 34 percent of outside-unclassified and 26 percent of commercial logging, forest activities, but the numbers of instances were low.

The converse is also the case; not all vegetation fires identified as malicious activity were classified as incendiary or suspicious within the ignition factor variable (only 89%). This reflects a number of different factors or situations. There were 144 instances (30%) of non-deliberate fires where malicious activity was implicated, in fires attributed to children (Table 2). According to AIRS guidelines, these should be classified as incendiary or suspicious. Approximately 35 percent of fires identified as non-deliberate child vegetation fires were probably malicious (incendiary or suspicious) in character. As noted previously, it is unclear how many other incendiary or suspicious fires were started by children.

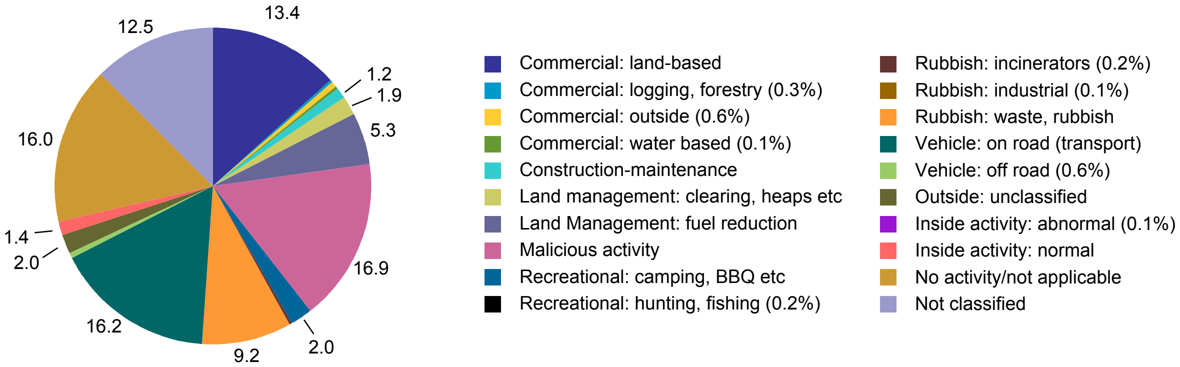
There were some scenarios where the link between malicious activity and the ignition factor was not intuitive, for example cutting and welding, lightning or high wind. It was assumed, for the purpose of this analysis, that these did not represent errors, but genuinely reflected the intentions of the fire officer who documented that fire. For example, in the case of lightning, although there may have been reason to suspect malicious activity in the area, there may have been additional factors (known to the recording officer) that indicated lightning as being the most probable cause. In the case of cutting or welding, the officer may have considered specific factors relating to a case, for example, that the person did not take the necessary precautions (including during fire restrictions or total fire bans) when cutting or welding.

There are other instances where ‘malicious activity in the area’ is consistent with a deliberate origin. Examples include misuse of heat of ignition, misuse of material ignited, unattended fires, flammable liquid used, etc. In these instances, the fire may genuinely have been deliberate, but this was not indicated in the ignition factor variable. As the classification is based on the ignition factor code, such instances would not have been included in either the suspicious or incendiary categories in this analysis. Overall, malicious activity was associated with 115 accidental (excludes fires caused by children), seven natural, nine reignition/exposure, nine other causes, and 199 unknown cause fires (Table 2).

Such issues are also pertinent to other causal categories. Although many fires started by lightning strikes were coded as no activity/not applicable, there was also a considerable number that fell within other human-related activity categories, such as ‘commercial land based’ activity (Table 3). Not surprisingly, fires for which the ignition factor was listed as ‘high wind’ (42% of natural fires), were distributed across many human-related activities, being particularly associated with fuel reduction burns and burning of waste heaps, rubbish and garden litter. It is highly likely that many of the fires within the high wind category should have been classified as accidental as opposed to natural, and that the proportion of natural fires was overestimated. Some confusion arises as there were also fires attributed to lightning strikes that fell within these categories.

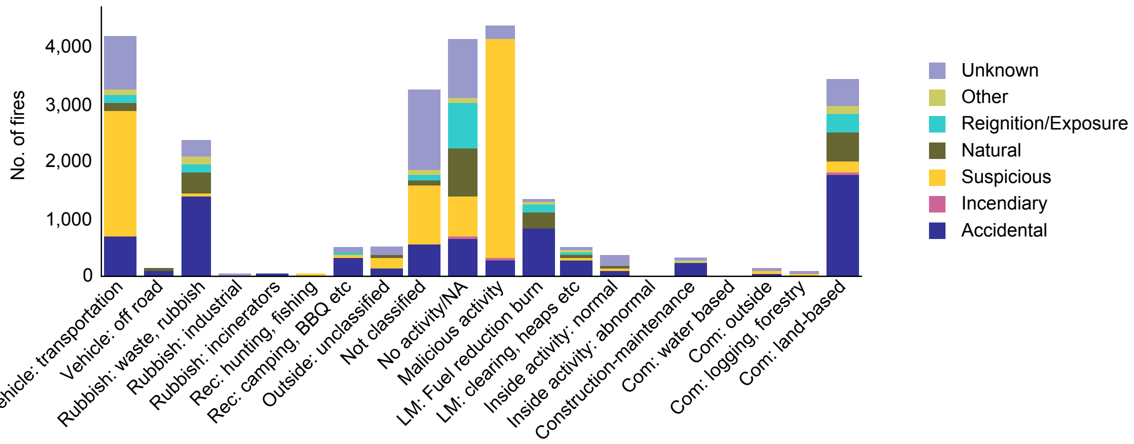
This discussion highlights that a classification based on neither the ignition factor nor the activity in the area is likely to enable an accurate assessment of fire causes. This is not a problem specific to the CFA, but is likely to be observed across all fire agencies; the CFA was the only agency for which both the activity in the area and the ignition factor code were available. A classification scheme that uses both components may prove valuable in the future. However, this approach may also encounter some difficulties, as it is problematic to assess how an officer classified fire attributes without being privy to detailed information about the fire. Moreover, such analysis would require more sophisticated and time-consuming analytical procedures. Modifications to the AIRS database to reduce confusion for officers coding the original fire data would assist subsequent analysis. Development of clear guidelines and definitions and training modules may improve fire officers' accurate and consistent recording of fire documentation.

Figure 51: Activity in the area, all vegetation fire causes (percent)



Source: CFA 1999–2000 to 2003–04 [computer file]

Figure 52: Relationship between activity in the area and fire cause (number)



Source: CFA 1999–2000 to 2003–04 [computer file]

Table 2: Classification of cause of fire where activity in the area was identified as malicious

Ignition factor	Accidental	Incendiary	Suspicious	Natural	Reignition/Exp.	Other	Unknown
Children 0–5	4						
Children 6–12	75						
Children 13–16	65						
Mental impairment	2						
Vehicle	28						
Misuse – heat of ignition; insufficient info/not classified	28						
Misuse – material ignited; insufficient info/not classified	17						
Abandoned, discarded material	14						
Flammable liquid used to kindle fire	13						
Inadequate control of open fire	6						
Combustible, too close to heat	2						
Spontaneous heating	2						
Cutting, welding	1						
Fuel spilled, released accidentally	1						
Other electrical failure	1						
Part failure, leak etc	1						
Unattended	1						
Incendiary		48					
Suspicious			3,804				
Lightning				6			
High wind				1			
Re-kindled					9		
Other ignition factor						9	
Ignition factor – Not determined							193
Ignition factor – Not applicable							6
(Total)	**(261)**	**(48)**	**(3,804)**	**(7)**	**(9)**	**(9)**	**(199)**

Source: CFA 1999–2000 to 2003–04 [computer file]

Table 3: Relationship between activity in the area and ignition factor for vegetation fires attributed to natural causes

Activity in area	High water	High wind	Lightning	Natural – not classified	Natural – insufficient information	Total
Commercial – land based		155	302	62	11	530
Commercial – logging, forestry		12	10	2		24
Commercial – outside		1	9	1		11
Commercial – water based			1			1
Construction – maintenance		2		4		6
Land Management – clearing, heaps etc.		53	1	10	2	66
Land Management – fuel reduction burn		221	1	42	10	274
Malicious activity		1	6			7
Recreational – camping, barbecue, etc.		12	5	6		23
Recreational – hunting, fishing		1				1
Rubbish – incinerators		3		2		5
Rubbish – industrial				1	2	3
Rubbish – waste, rubbish	4	328		30	4	366
Vehicle – transportation		59	59	20	6	144
Vehicle use – off road		1	1	1		3
Outside – unclassified		4	12	1		17
Inside activity – abnormal			2			2
Inside activity – normal		4	15	9	3	31
No activity	1	142	638	31	10	822
Not classified		15	62	14	8	99
(Total)	(5)	(1,014)	(1,124)	(236)	(56)	(2,435)

Source: CFA 1999–2000 to 2003–04 [computer file]

Figure 53: Tourism regions of Victoria

Source: Canberra: ABS 2005b

Location

Information about the location of fires is discussed in relation to the region in which the fire occurred, the density of fires at a postcode level, and the area of origin of the fire.

Region

The regions used in the analysis of CFA fires were based on the Victorian tourism regions, as defined by the Australian Bureau of Statistics for 2005 (Figure 53; ABS 2005b). The greatest number of CFA vegetation fires occurred in the Melbourne region (n=4,699 in five years), followed by the Gippsland, Bendigo–Loddon, Peninsula, Melbourne East, Goulburn and Western regions (Figure 54). The lowest frequencies occurred in Upper Yarra, Phillip Island, and the Spa Country. Overall, the greatest number of vegetation fires occurred in those regions with high populations, principally within or neighbouring the metropolitan centre of Melbourne or in regions containing major regional urban centres. The predominant causes of vegetation fires varied substantially between regions.

Overall, there was significant positive correlation ($r=.95$; $p<.001$) between the number of deliberate vegetation fires and the number of vegetation fires in each region (Figure 55). That is, there was a strong tendency for the number of deliberate vegetation fires to increase with increases in the total number of vegetation fires.

Nevertheless, the actual percentage of deliberate vegetation fires varied between 0 and 54 percent (Figure 54). The lowest percentage of deliberate vegetation fires occurred in the Wimmera and Western Grampians regions, the highest percentage occurred in the Geelong (54%), Melbourne (49%), Peninsula (48%), Ballarat (42%) and Bendigo–Loddon (37%) regions. The highest proportion of deliberate fires tended to occur in those regions that had moderate to high numbers of fires, but no direct correlation existed between the percentage of deliberate lightings and number of deliberate fires ($r=.66$; $p<.01$), principally because of the localised and differential impact of natural and accidental fires.

The greatest number of natural fires (including lightning strikes, high wind, high water, etc.) occurred in the Gippsland region, followed by the Western, Goulburn, Melbourne East, High Country, Western Grampians and Bendigo–Loddon regions (Figure 54). However, the highest proportion of natural fires (20 to 30%) occurred in the Western Grampians, Murray East, and Lakes regions (Figure 56). Overall, there was a tendency for natural fires to account for a higher proportion of vegetation fires in regions with comparatively lower total vegetation fire frequencies, and a low frequency of deliberate fires. Accidental fires formed the highest proportion of vegetation fires in the Wimmera, Central Murray and High Country regions.

The greatest number of non-deliberate child vegetation fires occurred in the Melbourne, Bendigo–Loddon, Peninsula, Gippsland, and Goulburn regions (Figure 57). Non-deliberate child vegetation fires made up a greater proportion (>2%) of fires in the Bendigo–Loddon, Central Murray and Grampians regions than in the Melbourne, Gippsland, Melbourne East and Western regions (<1.5%). Six to 12 year olds were responsible for a high proportion of non-deliberate child vegetation fires in the Ballarat and Western Grampians regions, whereas in the Geelong region, 13 to 16 year olds were the greatest contributors.

Table 4: Total number of postcodes with vegetation fires and deliberate fire frequencies within the specific ranges

Region	Melb.	Gippsland	Bendigo Loddon	Peninsula	East Melb.	Goulburn	Western	Geelong	Central Murray	High Country	Ballarat
No. postcodes recording a fire	81	49	28	29	45	29	66	15	29	25	9
No. postcodes where the total number of fires were in the following ranges:											
>299	3	–	1	–	–	1	–	1	–	–	1
200–299	3	3	3	2	–	–	1	–	1	2	1
100–199	8	1	–	5	5	5	2	2	1	1	1
50–99	14	9	5	6	6	6	4	3	4	2	2
25–49	16	12	9	7	15	7	14	7	8	5	2
0–24	37	24	10	9	19	10	45	2	15	15	2
No. postcodes where the number of deliberate fires were in the following ranges:											
>199	1	–	1	–	–	–	–	1	–	–	–
150–199	3	–	–	2	–	1	–	–	–	–	1
100–149	1	2	2	1	–	–	–	–	–	–	–
50–99	10	1	–	2	1	1	1	3	1	1	3
25–49	11	–	2	4	5	4	3	1	1	2	–
>0 & <25	43	37	18	17	30	18	45	10	24	16	4
No. postcodes recording a deliberate fire	69	40	23	26	36	24	49	15	26	19	8
% Deliberate	49.2	24.9	36.9	48.4	25.3	28.6	22.4	53.6	17.8	19.2	42.4

Table 4: Total number of postcodes with vegetation fires and deliberate fire frequencies within the specific ranges (continued)											
Region	**Mallee**	**Macedon**	**Murray East**	**Western Grampians**	**Lakes**	**Wimmera**	**Central Highlands**	**Spa Country**	**Phillip Island**	**Upper Yarra**	**Total**
All vegetation fires											
No. postcodes recording a fire	33	19	16	20	23	26	9	5	10	11	577
No. postcodes where the total number of fires were in the following ranges:											
>299	–	–	–	–	–	–	–	–	–	–	7
200–299	–	–	–	–	–	–	–	–	–	–	16
100–199	1	3	2	1	1	–	1	1	1	–	42
50–99	5	2	2	3	2	1	2	2	1	3	84
25–49	2	5	3	3	1	6	2	2	2	1	129
0–24	25	9	9	13	19	19	4	–	6	7	299
No. postcodes where the number of deliberate fires were in the following ranges:											
Deliberate vegetation fires											
>199	–	–	–	–	–	–	–	–	–	–	3
150–199	–	–	–	–	–	–	–	–	–	–	7
100–149	–	–	1	–	–	–	–	–	–	–	7
50–99	1	1	–	–	1	–	–	–	1	–	28
25–49	2	1	–	–	–	1	1	3	–	–	41
>0 & <25	22	15	14	12	12	13	5	2	7	9	373
No. postcodes recording a deliberate fire	25	17	15	12	13	14	6	5	8	9	459
% Deliberate	29.9	18.1	26.1	10.2	20.2	12.5	18.0	30.3	32.2	0.0	32.9

Source: CFA 1999–2000 to 2003–04 [computer file]

Postcode–suburb

Considerable heterogeneity existed in the density of vegetation fires generally, and the density of deliberate vegetation fires, specifically, within suburbs and postcodes in individual regions; the rate observed at a regional level did not necessarily reflect that occurring in a specific suburb.

All vegetation fires: Seven postcodes recorded in excess of 300 vegetation fires in five years (Table 4). Of these, three were in the Melbourne region and one each in the Bendigo–Loddon, Geelong, Ballarat and Goulburn regions (Figure 58), concentrated in those regions with the greatest total fire frequencies. These regions incorporate either metropolitan areas or a major regional centre. A further 16 postcodes recorded 200 to 299 fires, and 42 postcodes had 100 to 199 fires in five years.

A small number of postcodes contained a disproportionate number of vegetation fires. Almost one-third of vegetation fires the CFA attended occurred in the 23 postcodes that recorded in excess of 200 vegetation fires in five years. Almost half of all vegetation fires occurred in the 65 postcodes that recorded in excess of 100 vegetation fires in five years.

However, the extent to which vegetation fires were concentrated within specific postcodes varied markedly between regions. For example, in the Ballarat region 75 percent of vegetation fires occurred in the three postcodes that recorded in excess of 100 vegetation fires in five years, whereas in the Central Murray and Western regions, only 26 to 27 percent of vegetation fires occurred in the two or three postcodes that recorded 100 or more vegetation fires in five years. These differences likely reflect the variables of:

- size of the region
- number of postcodes within a region
- population densities and distributions within those regions.

For example, the large regional urban centre of Ballarat dominated the Ballarat region, with high population densities both within the city itself (approximately 90,000 people) and within the neighbouring semi-rural areas. Echuca (population approx. 10,000), the largest urban centre in the Central Murray region, lies within a principally agricultural region. The Western region is one of the largest regions in the state; the largest urban centres are at Warrnambool (pop. 32,000), Hamilton (pop. approx. 9,200), Portland (pop. approx. 12,000) and Colac (pop. approx. 14,000).

Overall, regions more distant from the metropolitan centre, with low population densities and few urban centres, have fewer vegetation fires, and although a single location (urban centre) may record a comparatively high number of vegetation fires (for example, greater than 100 vegetation fires in five years), the overwhelming majority of vegetation fires are sparsely distributed across many different postcodes. For example, in the Wimmera region, 64 percent of vegetation fires occurred in the 26 postcodes that recorded fewer than 25 vegetation fires in five years.

Deliberate vegetation fires: Commonly, 80 percent of postcodes within a region that experienced a vegetation fire of any cause also experienced at least one deliberate fire. However, in the Western Grampians, Lakes, Wimmera and Central Highlands regions only 50 to 60 percent of postcodes that experienced a vegetation fire documented a fire of deliberate origin.

The distribution of deliberate vegetation fires, as for vegetation fires generally, was highly variable both within and across regions (Figure 59). For example:

- Three postcodes in Victoria, in the Bendigo Loddon, Geelong and Melbourne regions, recorded in excess of 200 deliberate vegetation fires in five years. Approximately 10 percent of deliberate vegetation fires the CFA attended occurred in these three postcodes.

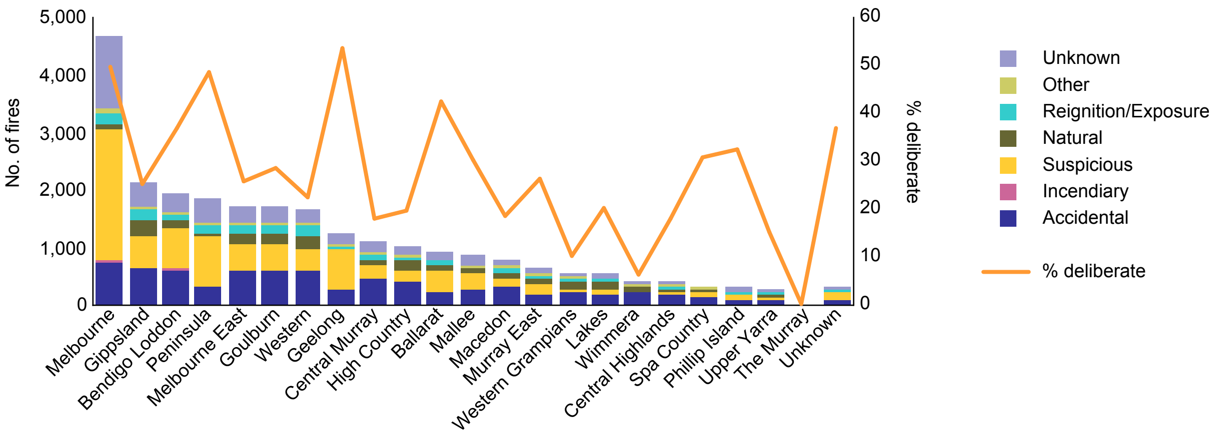
- A further seven postcodes recorded 150 to 199 deliberate vegetation fires. These postcodes, located in the Melbourne (three postcodes), Peninsula (two postcodes), Goulburn (one postcode) and Ballarat (one postcode) regions, accounted for 15 percent of deliberate CFA-attended vegetation fires.
- Another seven postcodes recorded 100 to 149 deliberate vegetation fires, of which two each occurred in the Gippsland and Bendigo–Loddon regions, and one each occurred in the Melbourne, Peninsula and Murray East regions. These seven postcodes accounted for 10 percent of deliberate vegetation fires.
- The 17 postcodes recording 100 or more deliberate fires accounted for one-third of deliberate vegetation fires the CFA attended in Victoria. These 17 postcodes represented less than three percent of all postcodes in Victoria (within the CFA's jurisdiction) to have recorded a vegetation fire of any type.

It is evident therefore, that regions with large population centres and high population densities were characterised by the highest numbers of deliberate vegetation fires (these include Melbourne, Geelong, Ballarat and Bendigo; Figure 59). A high proportion of deliberate vegetation fires within those regions tended to be associated with major urban centres.

Even in areas where low numbers of deliberate vegetation fires occurred, there tended to be a concentration of deliberate fires within specific postcodes, principally postcodes encompassing the major urban centre(s) in the region. For example, two-thirds of deliberate vegetation fires in the Murray East region occurred in the single postcode that encompasses the regional centre of Wodonga. Forty-six percent of vegetation fires in the Lakes region occurred in the postcode that encompasses Bairnsdale and Hillside. Forty-two percent of deliberate vegetation fires in the Central Highlands region occurred in the postcode that encompasses Ararat, even though the total number of deliberate vegetation fires in fire years in that postcode did not exceed 30 deliberate vegetation fires in five years.

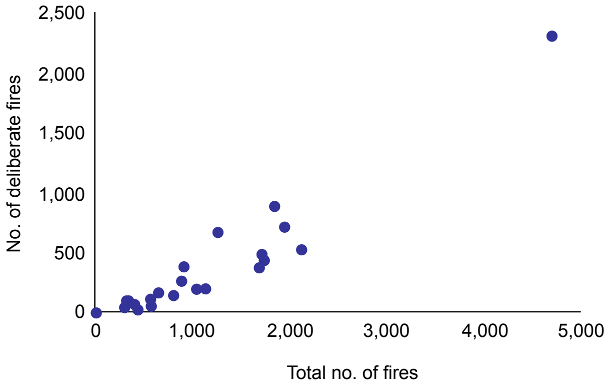
It is evident from Figure 59 that a greater proportion of fires in a region were deliberate, if that region incorporated one or more postcodes with very high numbers of deliberate fires. This reflects the tendency, at a suburb level, for the percentage of deliberate vegetation fires to increase with increasing numbers of deliberate vegetation fires (Figure 60). Greater numbers of deliberate vegetation fires typically occurred in urban areas. This could lead to a disparity in the rates of deliberate fires between urban and rural areas in the same region. For example, 47 percent of vegetation fires in Wangaratta (urban centre) were deliberately lit, compared with a region-wide value of 19 percent. It follows that the average rates of deliberate vegetation fires in areas outside of Wangaratta were actually lower than 19 percent. This example illustrates how differences in population densities generate disparities between regions, as the concentration of urban environments varies markedly across the state.

Figure 54: Fire cause, by region



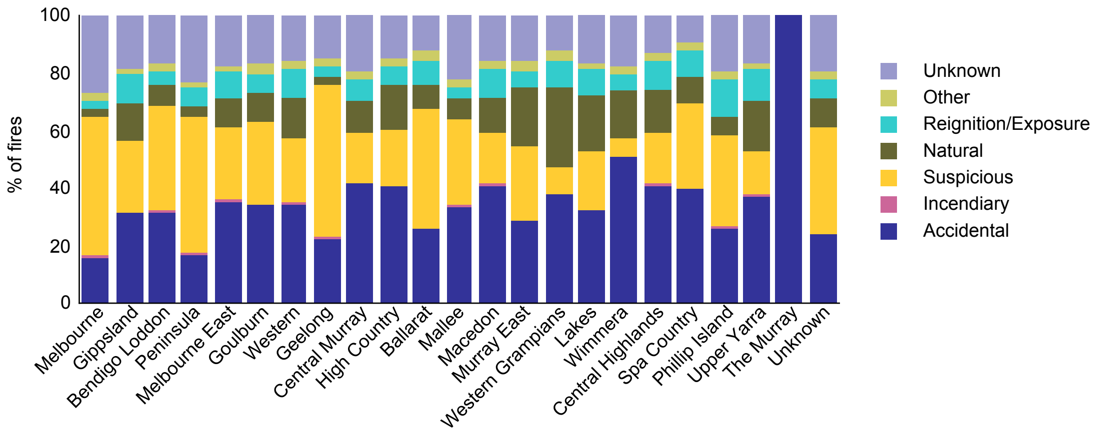
Source: CFA 1999–2000 to 2003–04 [computer file]

Figure 55: Relationship between number of vegetation fires and number of deliberate vegetation fires (number)



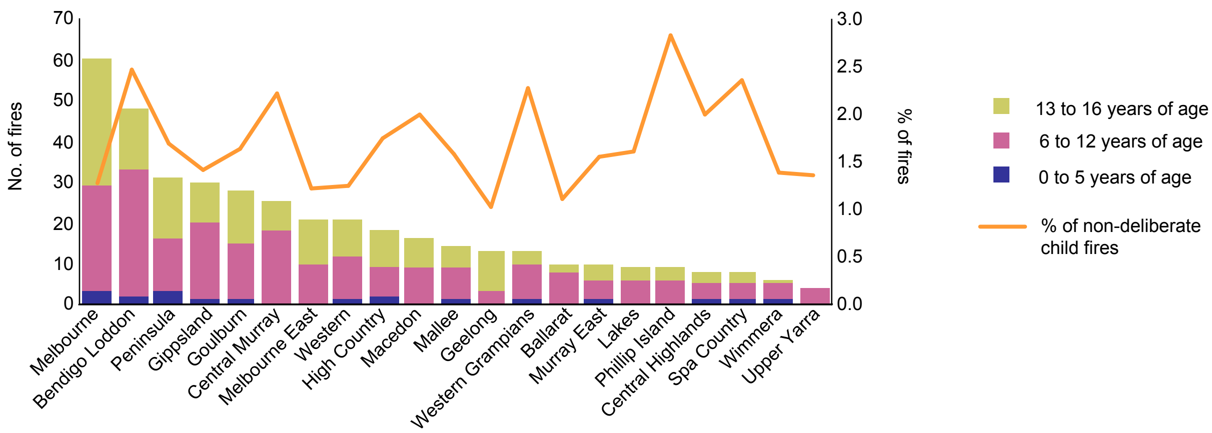
Source: CFA 1999–2000 to 2003–04 [computer file]

Figure 56: Fire cause, by region (percent)



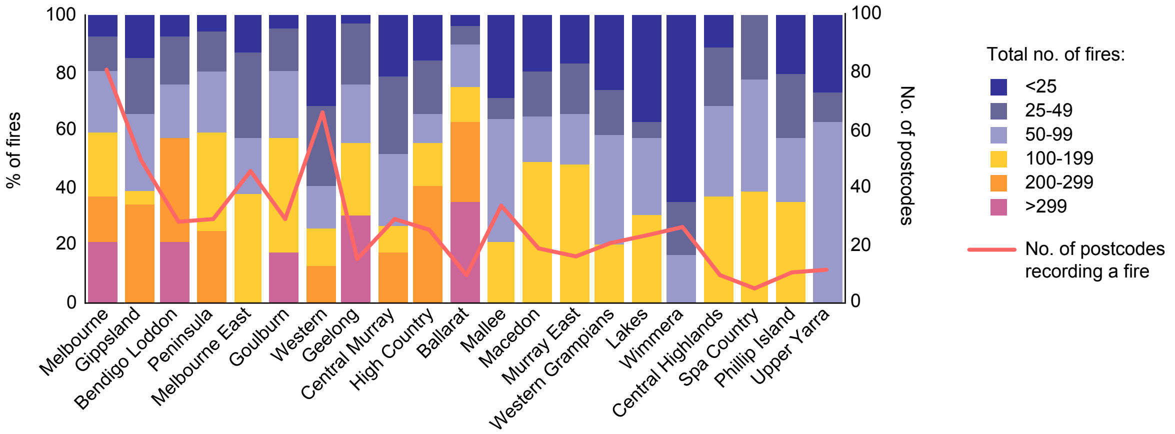
Source: CFA 1999–2000 to 2003–04 [computer file]

Figure 57: Non-deliberate child fire, by age and, by region (number)



Source: CFA 1999–2000 to 2003–04 [computer file]

Figure 58: Percentage of all fires that occur within postcodes within a region that record total vegetation fires within the documented ranges[a], by region[b]

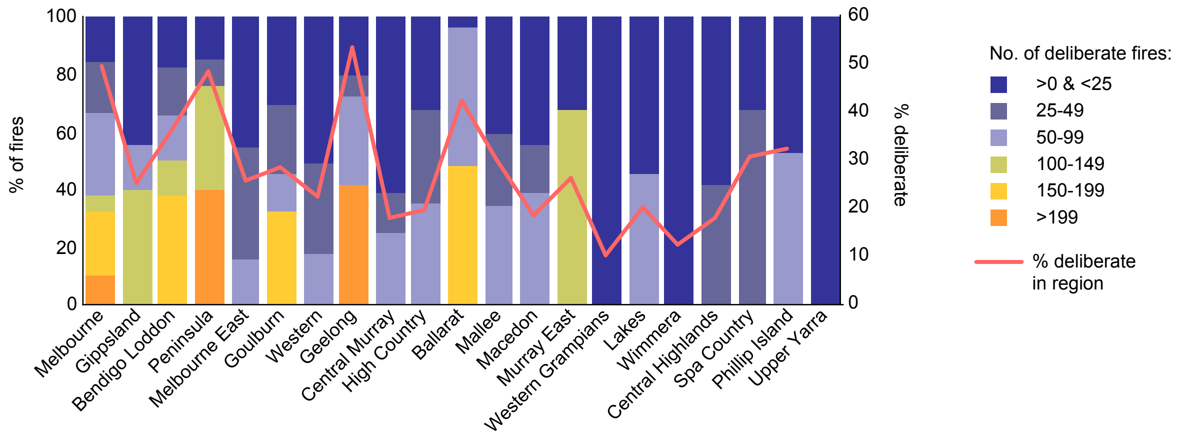


a: frequency ranges are based on total fire frequencies experienced over five-year interval

b: regions arranged in order of descending total fire frequency

Source: CFA 1999–2000 to 2003–04 [computer file]

Figure 59: The percentage of deliberate fires within a region that occurred within postcode that recorded deliberate fires within the documented ranges[a], by region[b]

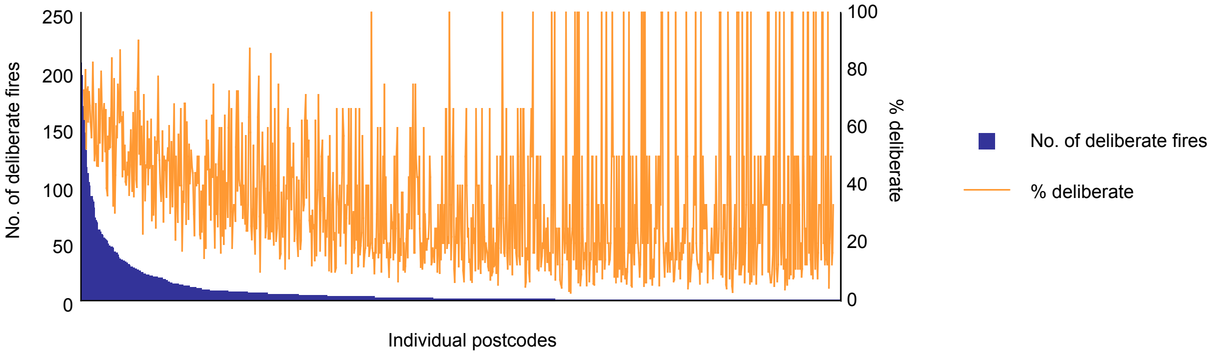


a: frequency ranges are based on deliberate fire frequencies experienced over five-year interval

b: regions arranged in order of descending total fire frequency

Source: CFA 1999–2000 to 2003–04 [computer file]

Figure 60: Number and percentage of deliberate fires in individual suburbs[a]



a: suburbs are arranged in order of decreasing numbers of deliberate fires (observed for a five-year period); suburbs identification have been removed intentionally

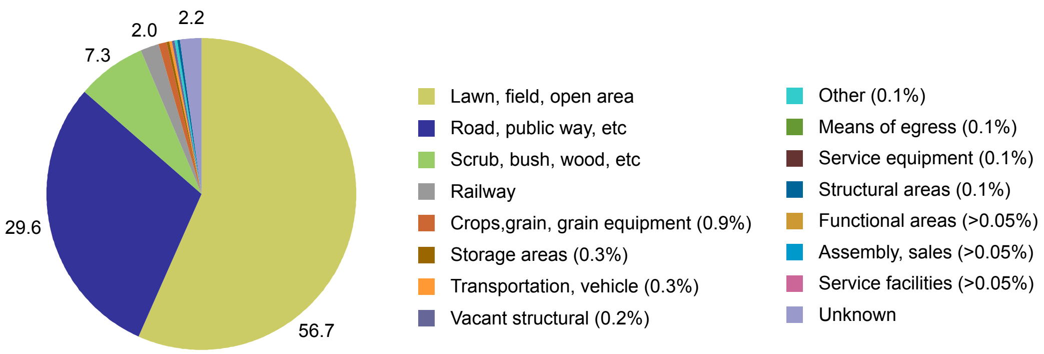
Source: CFA 1999–2000 to 2003–04 [computer file]

Area of origin

The area of origin analysis was based on AFAC-defined categories, within the variable titled 'Area of origin'. For 57 percent of vegetation fires the area of origin was lawns, fields and other open areas. A further 30 percent of vegetation fires occurred near roads, public ways and parking lots, with 7.3 percent occurring in scrub, bush or woods (Figure 61).

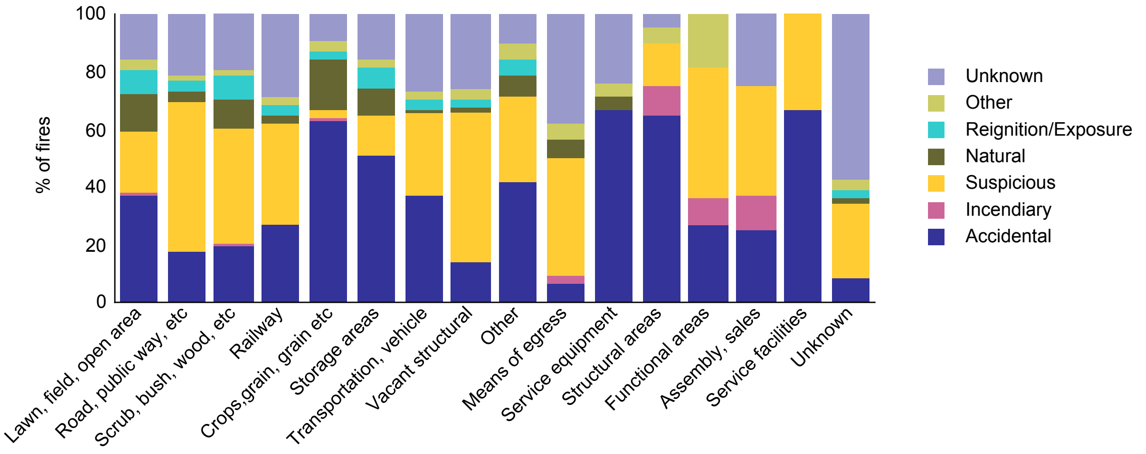
The extent to which deliberate causes contributed to total vegetation fire frequencies varied markedly between different area of origin types. For example, a high proportion (40 to 50%) of vegetation fires occurring in or near 'roads, public ways and parking lots', 'scrub, bush and woodlands', 'vacant structural' properties, and along 'means of egress' were deliberate (Figure 62). In contrast, a high proportion of vegetation fires associated with 'crops, grain and grain equipment', 'service equipment' and structural or storage areas were accidental. Overall, deliberate vegetation fires occurred more frequently near roads, public ways and parking lots (n=3,959) than on lawns, fields and other open areas (n=3,275) or in scrub, bush or woods (n=768).

Figure 61: Areas of origin for all vegetation fires (percent)



Source: CFA 1999–2000 to 2003–04 [computer file]

Figure 62: Cause and area of origin for all vegetation fires (percent)



Source: CFA 1999–2000 to 2003–04 [computer file]

Timing

The timing of fires was examined by week of the year, day of the week and time of the day.

Week of the year

Most CFA-attended vegetation fires occurred between mid November and mid May (Figure 63). Although generally similar to the timing of MFB and DSE fires, some differences were evident between agencies, mostly relating to differences in the principal causes of vegetation fires.

Differences were evident in the timing of vegetation fires from different causes or associated with different types of activities. Deliberate vegetation fires (principally vegetation fires labelled suspicious) mostly occurred between mid November and late April (Figure 63). The greatest number occurred between week 50 and week 4, coincident with the Christmas school holidays; natural fires also peaked in the same period. A smaller, narrower peak was also evident in week 11 (mid March). This pattern is broadly consistent with that for MFB deliberate fires.

Accidental fires broadly defined two distinct peaks (Christmas–New Year and mid April) but overall these peaks occurred somewhat earlier and later than those for deliberate vegetation fires (Figure 63). Although the majority of activities that gave rise to accidental fires peaked around Christmas–New Year and mid March, many accidental fires resulted from fuel reduction burns, and ‘burning waste heaps, rubbish and garden litter’. These activities typically occurred at the beginning and end of the fire season when there are lower risks of escape (Figure 64). This contributed to differences in timing relative to deliberate fires. It also contributed to the evident differences between the CFA and MFB, as comparatively few MFB-attended fires were as a result of fuel reduction burns or the clearing of rubbish.

The greatest number of natural fires occurred early in the New Year. Nevertheless, ‘natural’ fires the CFA attended occurred anywhere from late spring to early autumn. This reflected the fact that many fires within the natural category were actually started by human beings but natural conditions contributed to their escape. Many of the fires in spring and autumn were associated with fuel reduction burns, or the burning of rubbish heaps or other waste.

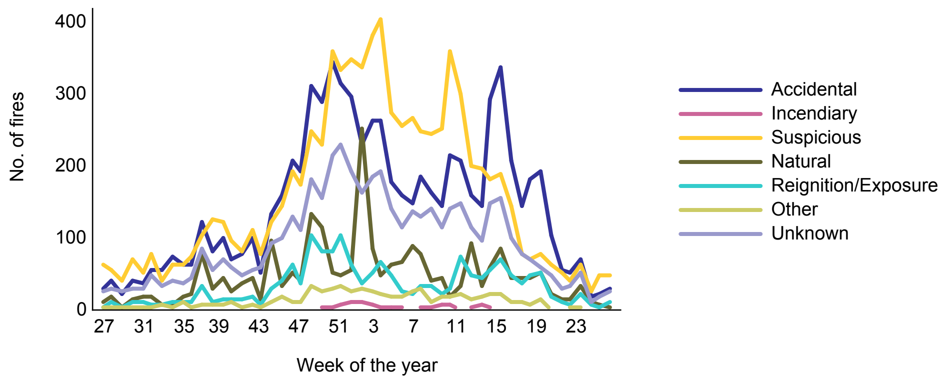
There was an exceptionally strong relationship between the timing of vegetation fires where there was malicious activity in the area, and vegetation fires associated with vehicles (transportation; Figure 65). This may reflect the fact that half of all vehicle (transportation) fires were deliberate.

Climatic conditions vary across the state, giving rise to subtle differences in the predominant fire regime. Such regional climatic variations are likely to be insignificant compared with regional differences in human activities; for example, the propensity for, and timing of, fuel-reduction burns and specific agricultural practices varies regionally according to predominant land use patterns. Both regional variations in climatic conditions and land use patterns are likely to have a subordinate impact relative to the climatic variations that occur from year to year.

In 1999–2000 and 2000–01, there were large spikes in the number of vegetation fires in December–January, followed by reduced fire frequencies throughout the remainder of the bushfire season (Figure 66). In contrast, in 2001–02 and 2003–04, the number of fires was more evenly distributed across the bushfire danger season. 2002–03 was remarkable as high numbers of vegetation fires occurred as early as mid September and remained high until late February. Low numbers of vegetation fires occurred between late February and May. This may reflect the fact that extensive vegetation fires throughout much of the northeast negated the usual need for land management activities (for example, burn offs) at this time.

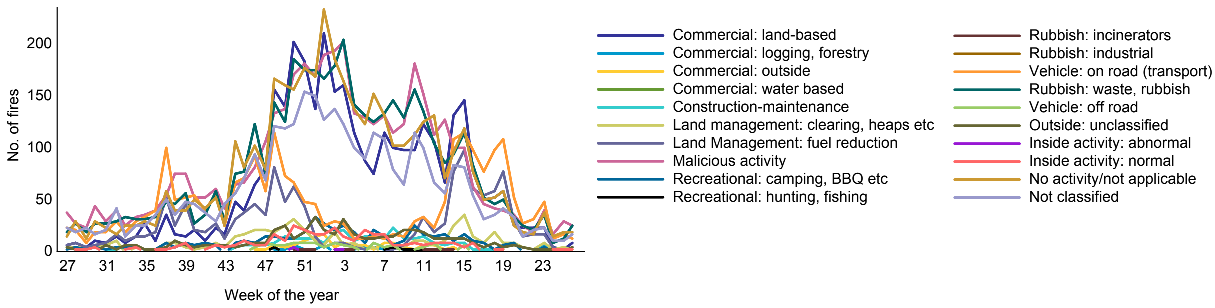
Most non-deliberate child vegetation fires occurred from mid November to late April (Figure 67). The available data indicate that the timing these fires most strongly parallels the distribution described for accidental fires, with peaks in activity lying outside the typical range observed for deliberate fires. However, some caution is needed when drawing significant conclusions from these data, due to the comparatively small number of vegetation fires involved.

Figure 63: Vegetation fires, by week and cause (number)



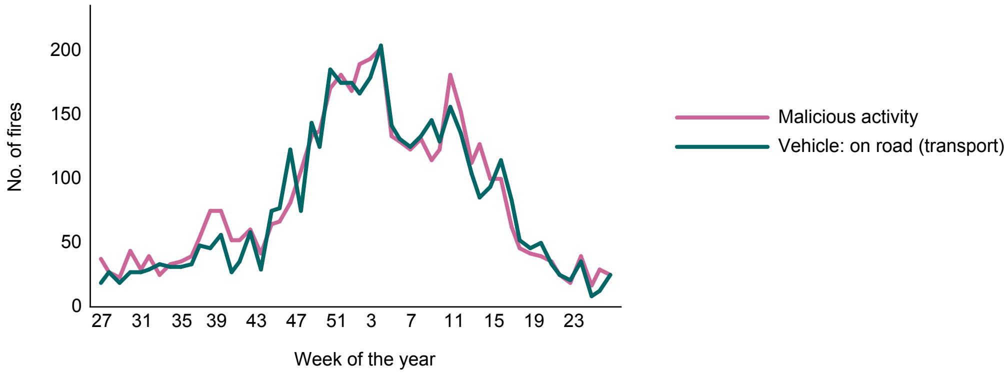
Source: CFA 1999–2000 to 2003–04 [computer file]

Figure 64: Vegetation fires, by week and 'activity in the area' (percent)



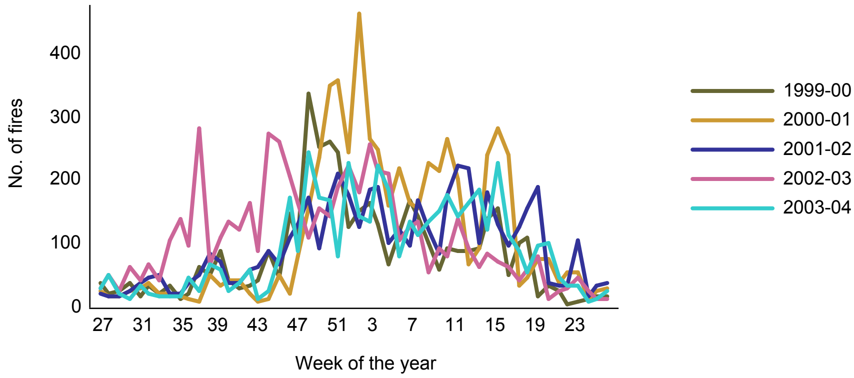
Source: CFA 1999–2000 to 2003–04 [computer file]

Figure 65: Malicious and transportation vegetation fires, by week (number)



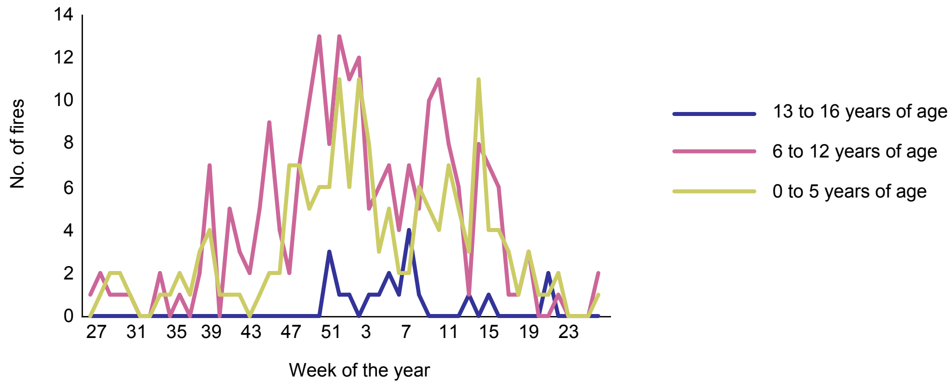
Source: CFA 1999–2000 to 2003–04 [computer file]

Figure 66: Vegetation fires, by week and year (number)



Source: CFA 1999–2000 to 2003–04 [computer file]

Figure 67: Non-deliberate vegetation fires lit by children, by year (number)



Source: CFA 1999–2000 to 2003–04 [computer file]

Day of the week

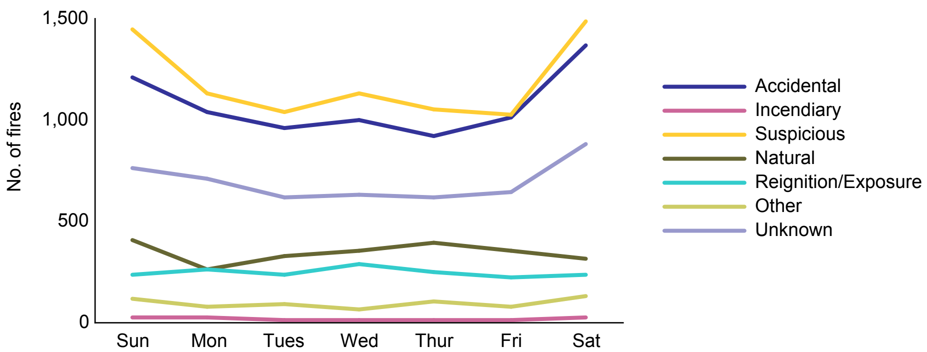
Approximately 1.2 times more vegetation fires occurred on Sunday, and 1.3 times more on Saturday, than on the average weekday. Nevertheless, the tendency for higher numbers of weekend fires was highly cause specific (Figure 68). Not surprisingly, no weekend bias was evident for natural fires or fires resulting from reignition-exposure. Approximately 1.2 and 1.4 times more accidental vegetation fires occurred on Sunday and Saturday, respectively, than on the average weekday. Between 1.9 and 2.1 times more incendiary fires occurred on weekend days than on the average weekday. This bias was less evident for suspicious vegetation fires, where 1.3 to 1.4 times more vegetation fires occurred on Saturday and Sunday.

Understandably, the type of vegetation fires on weekends related to the type of activity in the area (Figure 69). For example, approximately 2.3 to 2.5 times more vegetation fires associated with recreational activities, such as camping, picnicking and barbecues, occurred on a Saturday or Sunday than on the average weekday. Similarly, 1.4 to 1.6 times more vegetation fires associated with incinerators and the burning of rubbish, waste and garden litter occurred on a weekend day than on the average weekday. Not surprisingly, given normal working hours, no increase in the number of industrial rubbish vegetation fires occurred on weekends.

Although vegetation fires associated with commercial land-based activities were only 12 to 13 percent more likely to occur on a weekend, 30 to 40 percent more vegetation fires pertaining to land management activities, such as fuel reduction burning, the clearing of land, heaps and windrows, occurred on weekends, highlighting that a different subset of the population may be engaged in these activities.

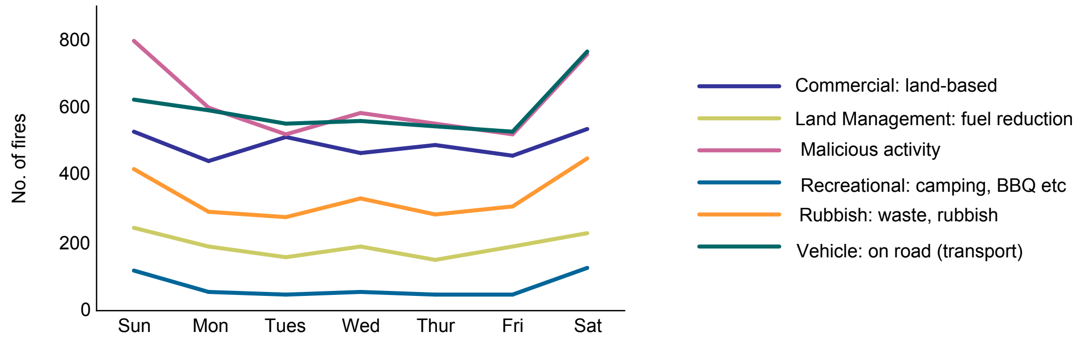
Despite the fact that many non-deliberate vegetation fires occurred during the school holidays, children lit 1.75 and two times more vegetation fires on Sunday and Saturday, respectively, than on the average weekday. This was evident for both 6 to 12 and 13 to 16 year olds (Figure 70). A greater number of 13 to 16 year olds caused vegetation fires on Sunday than on Saturday. The number of fires lit by 6 to 12 year olds decreased as the week progressed but increased markedly on Saturday.

Figure 68: Vegetation fires, by day of the week and cause (number)



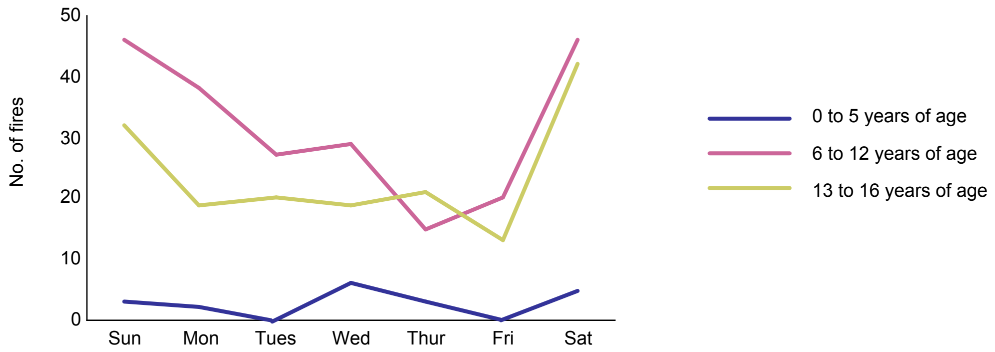
Source: CFA 1999–2000 to 2003–04 [computer file]

Figure 69: Vegetation fires, by day of the week and activity (percent)



Source: CFA 1999–2000 to 2003–04 [computer file]

Figure 70: Non-deliberate child fires, by day of the week and age group (number)



Source: CFA 1999–2000 to 2003–04 [computer file]

Time of day

The time each incident occurred was available for more than 99.9 percent of CFA-attended vegetation fires from 1999–2000 to 2003–04. As observed elsewhere, the distribution of detection times varied markedly between deliberate and non-deliberate vegetation fires.

Accidental fires principally occurred during daylight hours, peaking at 2 to 3 pm (Figure 71). Natural fires, from lightning and other causes, occurred within a similar timeframe, although peak numbers were from 2 to 4 pm; similar trends occurred for 'other' and reignition/exposure categories.

In contrast, deliberate fires occurred throughout the day, with fires during both the daytime (working hours) and the night-time (conventional leisure hours). Like non-deliberate fires, the greatest number of deliberate fires occurred during the daytime. However, the greatest number of deliberate vegetation fires occurred between 4 and 6 pm, later than the 2 to 3 pm peak time for accidental fires.

Substantial differences also existed in the number and proportion of night-time fires. Forty-five percent of all deliberate fires occurred between 6 pm and 6 am, compared with 23 percent of accidental fires. The differences between non-deliberate and deliberate causes were most evident for the interval between 12 and 6 am. Notably, 14.3 percent of all deliberate fires occurred within this timeframe, compared with just 3.4 percent of accidental fires.

Overall, the proportion of deliberate vegetation fires that occurred between 6 pm and 6 am was similar to that observed by the MFB for deliberate vegetation fires. Nevertheless, there is a clear distinction between the distribution of MFB and CFA deliberate vegetation fires. In contrast to the MFB, the number of fires occurring between 7 and 12 pm was distinctly lower than the daytime maximum. This probably highlights a fundamentally different balance between the principal contributors to deliberate fires for these jurisdictions.

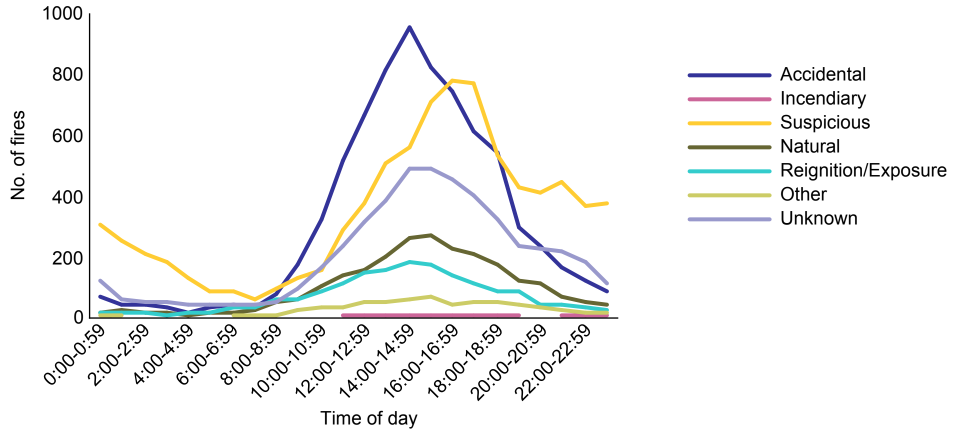
It is easier to comprehend the difference between accidental and deliberate vegetation fires when the day of the week on which the fire occurred is taken into account. Unlike accidental fires, where the only noticeable difference is an increased number of daytime fires on the weekend (Figure 72), there were clear differences between the distribution of deliberate vegetation fires on weekends and on weekdays (Figure 73). The distribution of deliberate vegetation fires on weekends was similar to that observed for accidental fires with peak numbers of deliberate vegetation fires occurring at 3 to 4 pm, emphasising that was the weekday distributions that were skewed toward later times (Figure 73). The increase in the number of deliberate fires between 4 and 6 pm on weekdays, but not weekends, indicates that children or adults on the way to or from school or work may have lit many of the deliberate daytime fires. Most non-deliberate child vegetation fires occurred from 5 to 6 pm (Figure 74).

The number of deliberate fires between 6 pm and 6 am was higher on Friday night–Saturday morning and Saturday night–Sunday morning. However, owing the higher frequency of daytime fires, the actual proportion of deliberate fires that occurred within this timeframe was comparable across all days of the week. The most notable difference for deliberate vegetation fires on weekends and weekdays occurred for fires between midnight and 6 am. On Saturday and Sunday, 19 to 20 percent of all deliberate fires occurred within this timeframe, whereas on weekdays, it was typically 10 to 12 percent. The exception was Wednesday night, where 14 percent of deliberate fires occurred from 12 to 6 am. The timing of deliberate night-time fires was consistent with deliberate fires on the way to or from social activities. However, greater numbers of fires on weekends stemmed from higher numbers of both day and night-time fires.

The trends outlined above are the agglomeration of trends that occurred across the state, and are not necessarily representative of the trends at a local scale. At a regional level, the percentage of fires that occurred between 6 pm and 6 am varied from a low of 45 percent for Macedon to a high of 60 percent for the Wimmera region (Figure 75). Typically, 10 to 20 percent of all fires within a region occurred between midnight and 6 am, but levels were locally higher in the Wimmera (30%) and Geelong (23%) and lower in the Macedon (6%) and Spa Country (8%) regions (Figure 75).

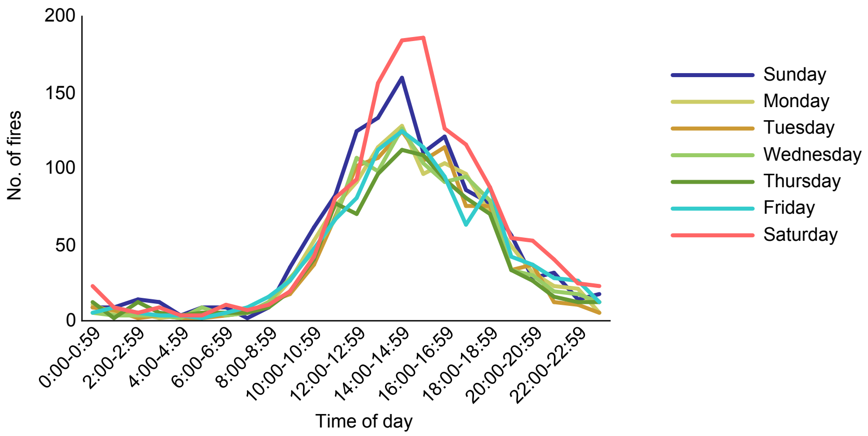
To examine the tendency for deliberate fires to occur on some nights of the week it is necessary to examine contiguous timeframes from 6 pm to midnight on one day and from midnight to 6 am on the following morning. Deliberate fires on Friday night–Saturday morning and Saturday night–Sunday morning accounted for between 18 and 49 percent of all deliberate fires that occurred between 6 pm and 6 am (values less than 29 percent indicate less night-time fires on weekends and values greater than 29 indicate more night-time fires on weekends than might be expected from an even distribution throughout the week). The greatest percentage of night-time fires occurred on Friday night–Saturday morning and Saturday night–Sunday morning in the Lakes (49%), Mallee (46%) and Melbourne East (45%) regions, whereas the lowest proportions occurred in the Macedon (18%), Central Highlands (24%) and Western Grampians (27%) regions (Figure 75). Obviously, regional trends are also an agglomeration of trends that occurred at a local scale, and to reduce deliberate fires, local trends should be identified and appropriate strategies implemented.

Figure 71: The time of day fires occurred, by cause (number)



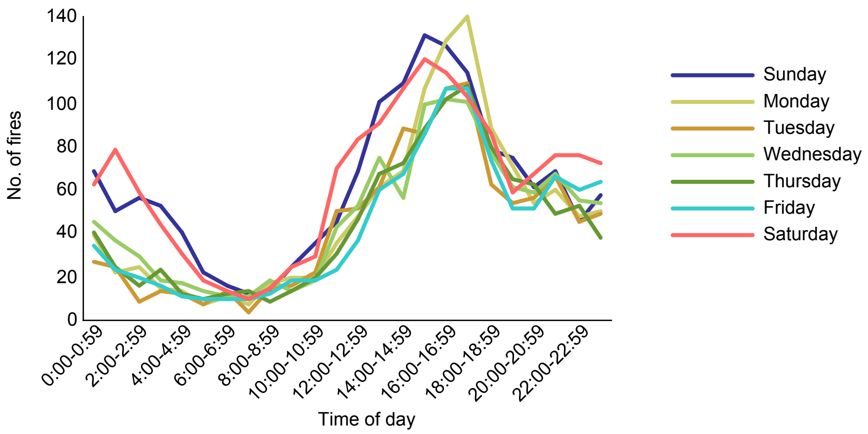
Source: CFA 1999–2000 to 2003–04 [computer file]

Figure 72: Accidental fires by, time of day, by day of the week (number)



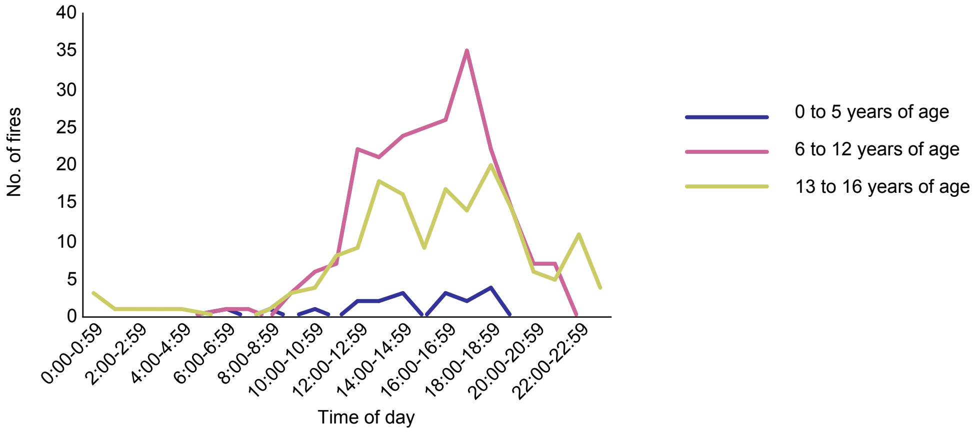
Source: CFA 1999–2000 to 2003–04 [computer file]

Figure 73: Deliberate fires by, time of day, by day of the week (number)



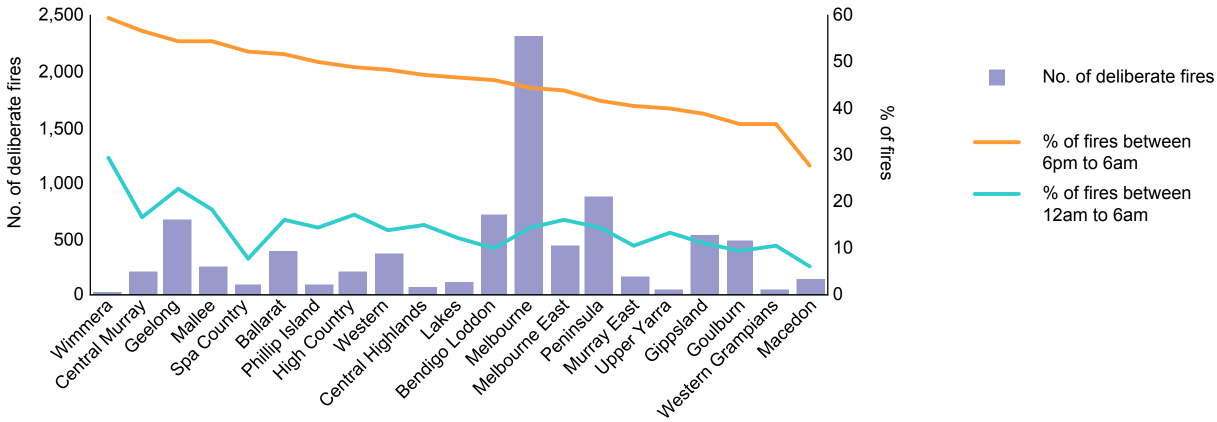
Source: CFA 1999–2000 to 2003–04 [computer file]

Figure 74: Non-deliberate child fires by, time of day, by day of the week (number)



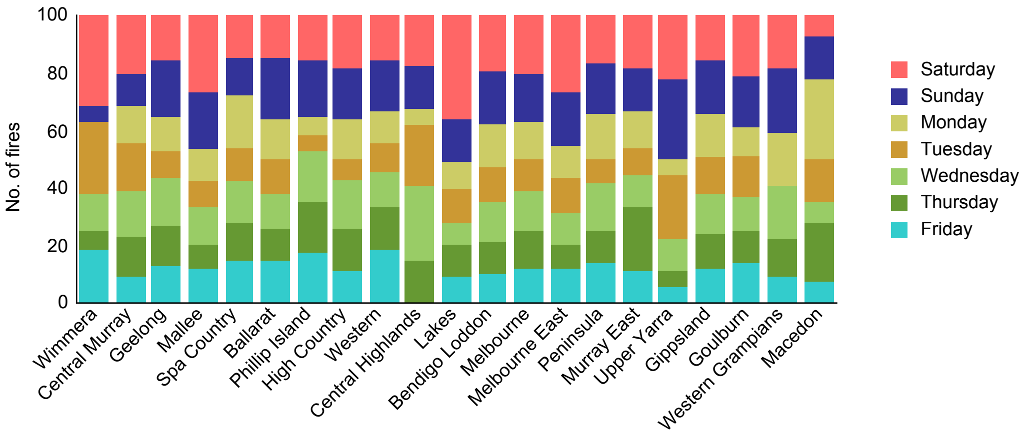
Source: CFA 1999–2000 to 2003–04 [computer file]

Figure 75: Deliberate fires at night, by region (number)



Source: CFA 1999–2000 to 2003–04 [computer file]

Figure 76: Deliberate fires between 6 pm and 6 am for contiguous night–mornings, in each region (percent)



Source: CFA 1999–2000 to 2003–04 [computer file]

Area burned

The number of vegetation fires of a given size decreased with increasing total area burned, with the characteristic hump in the pattern for the 10 to 49.9 and 100 to 499 ha categories. This pattern occurred irrespective of cause (Figure 77).

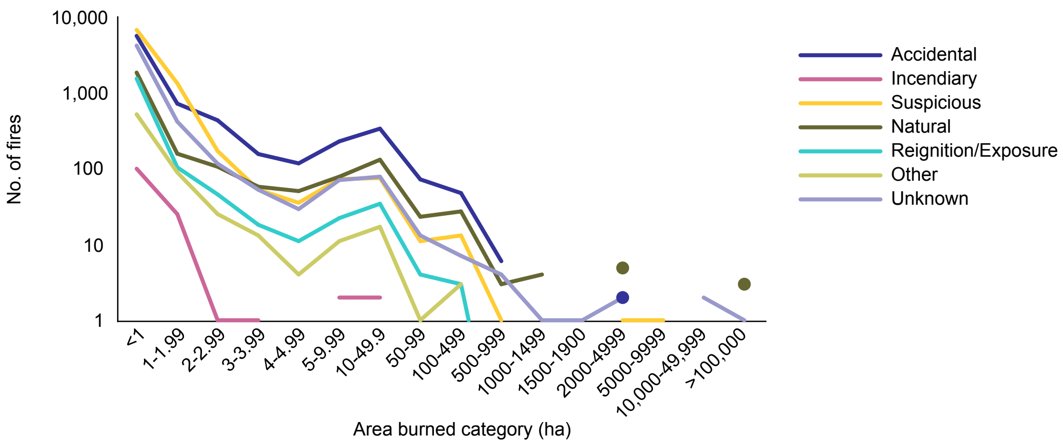
Overall, deliberate causes accounted for a decreasing proportion of fires as the size of the vegetation fire increased (Figure 78). Of the 25 fires that burned 1,000 ha or more, only two were suspicious. The largest burned 6,100 ha in the Goulburn region in 2001–02; the other burned 3,000 ha in the Central Highlands in 1999–2000. Only one suspicious fire fell within the 500 to 999 ha range, and 13 fires in the 100 to 499 ha range were suspicious. The largest fires labelled incendiary burned 12 ha.

The majority of large vegetation fires were either natural or of unknown origin. Of the 12 natural fires that burned 1,000 ha or more eight were the result of lightning. Lightning was responsible for the three largest fires the CFA attended; these burned 175,455 ha, 307,542 ha and 326,180 ha in the Lakes, High Country and Murray East regions respectively, all during 2002–03. The largest natural fire not related to lightning was attributed to high wind. This fire burned 4,537 ha in the Lakes region in 2003–04. One fire of unknown cause burned 271,479 ha in the Lakes region in 2002–03, with another two fires of 10,000 ha burning in the Central Highlands and High Country regions in 2000–01 and 2002–03 respectively.

Approximately 1.2 million hectares was burned in CFA-attended vegetation fires from 1999–2000 to 2003–04. Clearly, the total area burned was dominated by large fire events. Hence, approximately 70 percent of the total area was burned in fires of natural causes (principally lightning), of which a further one-quarter was burned by fires of unknown causes (Figure 79). Deliberate fires (principally suspicious rather than incendiary) accounted for only 1.4 percent of the total area burned.

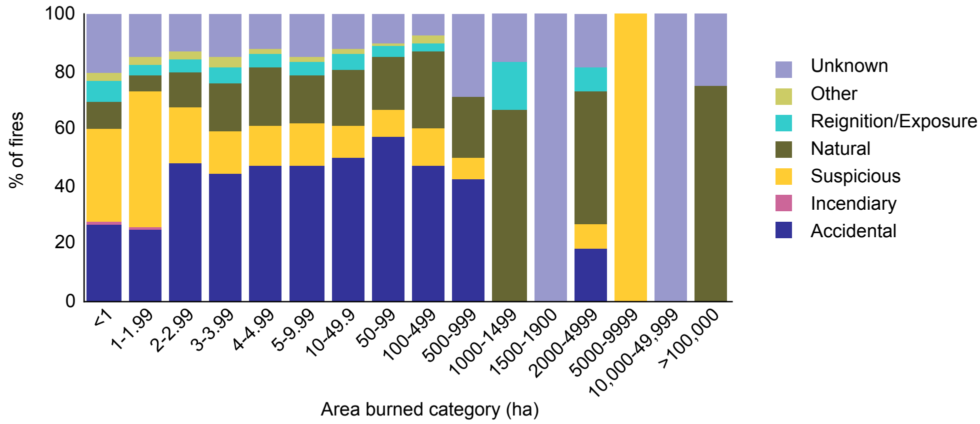
The overwhelming majority of the total area burned was burned in 2002–03 (Figure 80), in the northeast of the state. The largest area burned by deliberate fires occurred in 2001–02 (total deliberate = 7,495 ha) and in 1999–2000 (total deliberate = 3,893 ha), with the total area burned by deliberate fires in those years being dominated by the two large suspicious fires outlined above. In those two years, deliberate fires were responsible for almost 30 percent of the total area burned. Deliberate fires burned 2,312 ha in 2002–03 and less than 1,500 ha in 2000–01 and 2003–04. In the latter two years, deliberate fires comprised less than six percent of the total area burned.

Figure 77: Area burned category (ha), by cause (number)



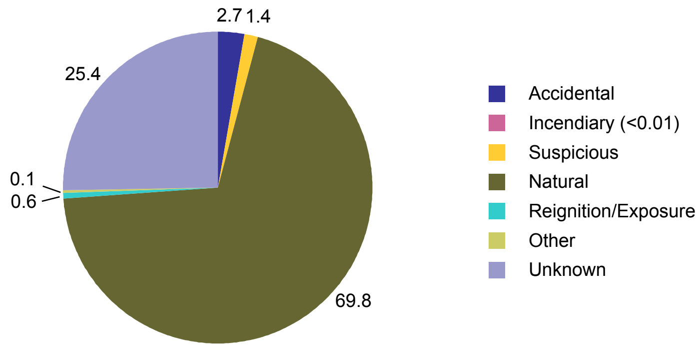
Source: CFA 1999–2000 to 2003–04 [computer file]

Figure 78: Area burned category (ha), by cause (percent)



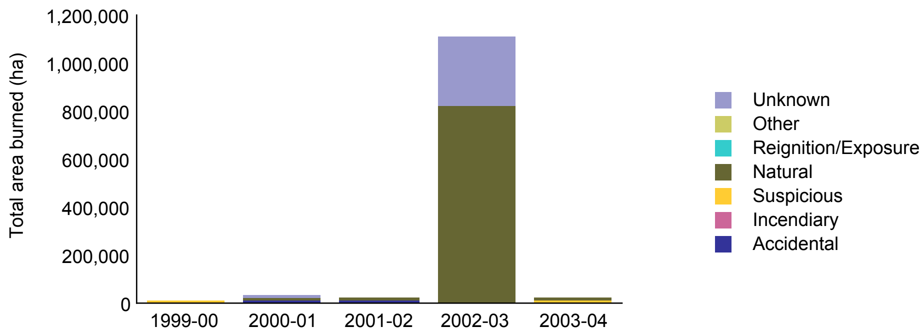
Source: CFA 1999–2000 to 2003–04 [computer file]

Figure 79: Total area burned in vegetation fires, by cause (percent)



Source: CFA 1999–2000 to 2003–04 [computer file]

Figure 80: Total area burned by vegetation fires each year, by each cause (number)



Source: CFA 1999–2000 to 2003–04 [computer file]

Type of incident

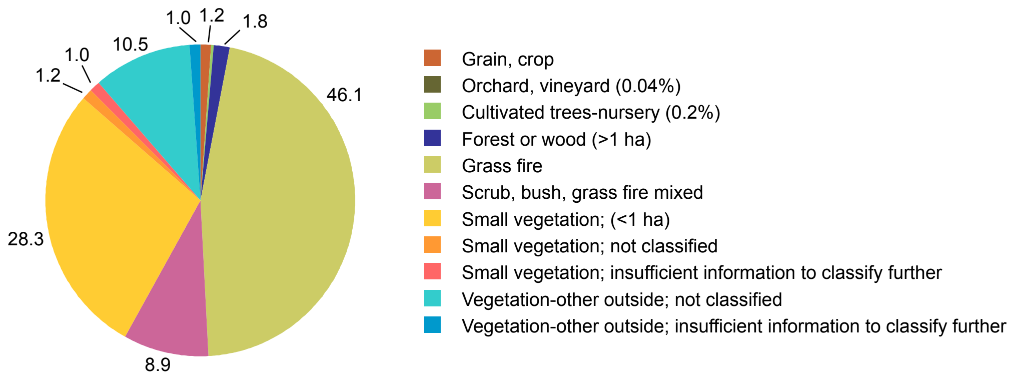
Forty-six percent of vegetation fires the CFA attended were classified as grassfires, with a further 31 percent being small vegetation fires (Figure 81). A further nine percent were mixed scrub, bush and grass fires and 12 percent other vegetation and outside fires. Only 1.8 percent of fires were forest or wood fires.

Deliberate causes were responsible for 26 to 38 percent of all incident types with the exception of grain and crop fires and fires that occurred in orchards/vineyards/nurseries (Figure 82). While comparatively few (2%) grain and crop fires were deliberate, half of all fires in orchards/vineyards/nurseries (including cultivated tree fires) resulted from deliberate causes. Grassfires were more likely to have been classified as deliberate (38%) than fires in forest and woods (26%).

Collectively, the proportion of grass and small vegetation fires combined was remarkably constant (typically 70 to 80%) across Victorian regions, although the ratio between small vegetation fires and grassfires varied markedly in detail (Figure 83). There was an antipathetic relationship between the two, with areas characterised by a high proportion of grassfires having a lower proportion of small vegetation fires and vice versa. Areas with a high proportion of grassfires included the Melbourne, Geelong and Ballarat regions. Areas with a higher proportion of small vegetation fires included Phillip Island, Macedon, and the Central Murray regions; and a higher than normal proportion of mixed scrub, bush and grass fires occurred in the Spa Country. Not surprisingly, given land use patterns, a higher proportion of fires that occurred in the Wimmera region were grain or crop fires.

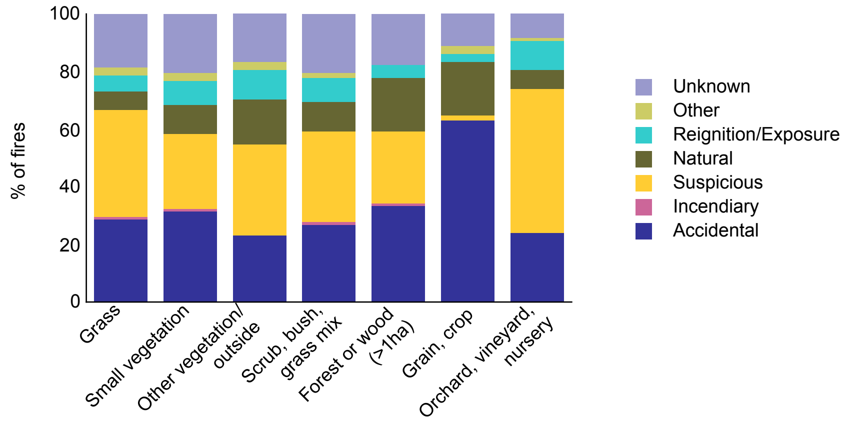
It is impossible to assess, from the available data, how many fires were bushfires or had the potential to develop into a bushfire. However, it is evident that there was a significant positive correlation between the number of grass, forest/wood, and mixed scrub/bush/grass fires combined ($r=.98$; $p<.001$) and the total number of vegetation fires within a given region (Figure 84). A significant positive relationship ($r=.94$; $p<.001$) also existed between the number of forest/wood and mixed scrub/bush/grass fires (combined) and the total number of vegetation fires within a given region (Figure 84). Hence, even though it was difficult to specify what proportion of fires potentially constituted a bushfire, there was likely a strong relationship between the distribution of bushfires specifically and the distribution of vegetation fires generally.

Figure 81: Type of vegetation fire incident (percent)



Source: CFA 1999–2000 to 2003–04 [computer file]

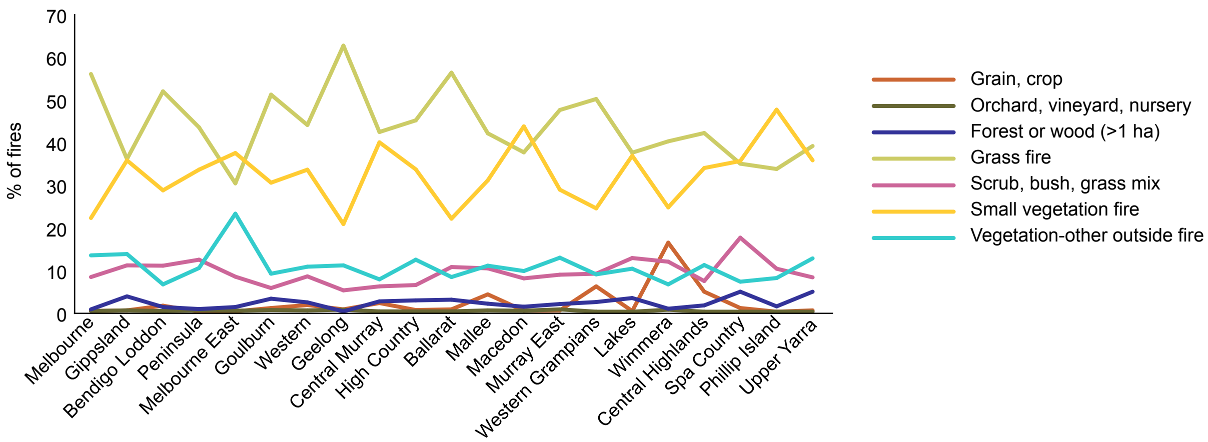
Figure 82: Cause of each incident type[a] (percent)



a: incident type arranged in order of decreasing frequency

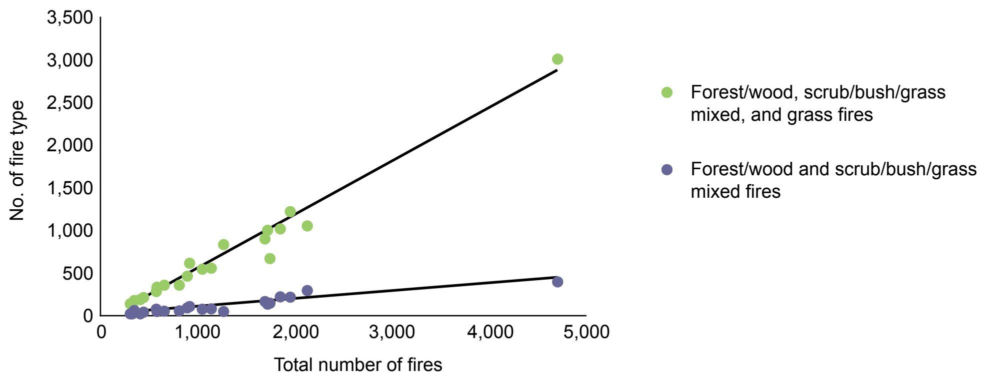
Source: CFA 19599–2000 to 2003–04 [computer file]

Figure 83: Type of incidents in each region (percent)



Source: CFA 1999–2000 to 2003–04 [computer file]

Figure 84: Relationship between specific incident types and the total number of vegetation fires in each region (number)



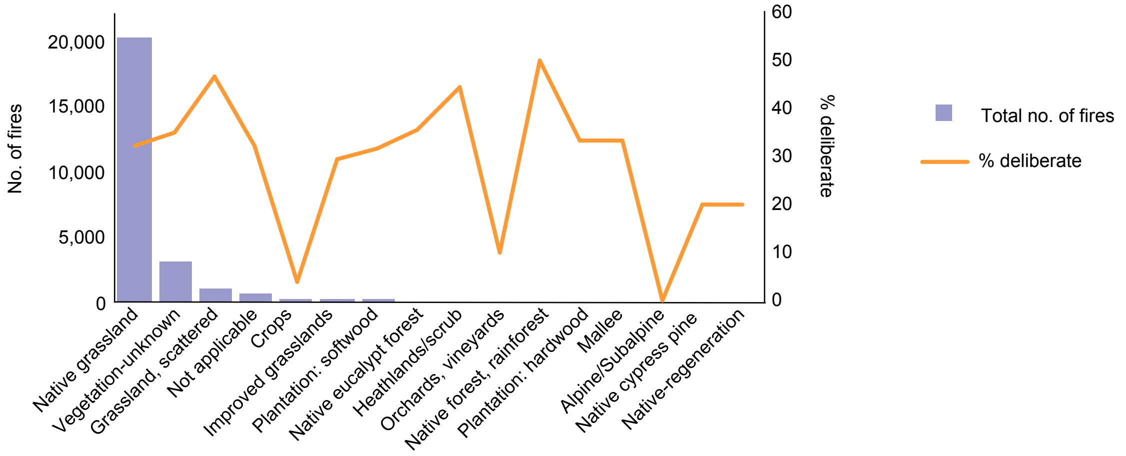
Source: CFA 1999–2000 to 2003–04 [computer file]

Vegetation burned

Information about the primary vegetation type affected was available in 96 percent of cases. In keeping with the incident type documented above, 78 percent of fires, where the type of vegetation was assigned, occurred in native grassland (Figure 85). A further 3.7 percent occurred in grasslands in which there were scattered trees. Only one-third of the fires in native grasslands were native hummock grasslands. The remainder were in grasslands that could be grazed.

A comparatively high proportion of fires in grasslands, heath lands and scrub, and in native rainforests were deliberate in origin. Low proportions of crop fires, fires in orchards and vineyards and alpine or sub-alpine vegetation were deliberate.

Figure 85: Number of fires, percentage of deliberate fires, within each vegetation type



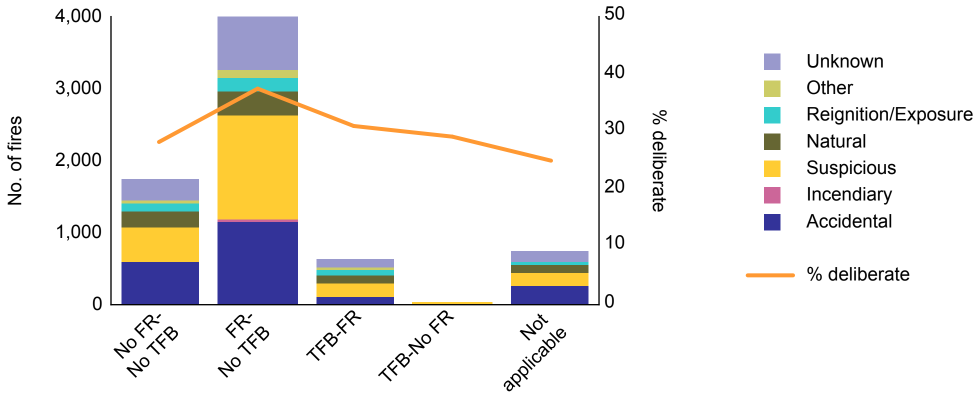
Source: CFA 1999–2000 to 2003–04 [computer file]

Fire restrictions/total fire bans

The status of fire restrictions and total fire bans, including instances where not applicable values were assigned (2.9%), were available for 27.8 percent of vegetation fires. Of these, 24 percent occurred under conditions when there was neither fire restrictions or a total fire ban in force and 56 percent occurred when there were fire restrictions but no total fire ban (Figure 86). A further nine percent occurred when both restrictions and a ban was in force, with just 0.7 percent of fires occurring when there was a total fire ban and no fire restrictions.

The highest proportion of deliberate fires (37%) occurred under conditions when there were fire restrictions but no total fire ban in place. This value decreased to 30 percent or less when a total fire ban was in place.

Figure 86: Cause of vegetation fires under different fire restrictions[a]



a: FR = fire restrictions; TFB = total fire ban

Source: CFA 1999–2000 to 2003–04 [computer file]

Combined agency analysis

This section combines data from both the MFB and CFA to yield an overview of vegetation fires in Victoria. However, in order to do this it is first necessary to compare and contrast data from these two agencies in order to highlight issues pertaining to cross-agency comparisons. In order to eliminate differences introduced by yearly variations the analysis is restricted to data from 1999–2000 to 2001–02; that is, years for which data was available for both agencies. The analysis is broken into two components:

- Combined MFB and CFA data for the Melbourne and Melbourne East regions
- MFB and CFA population analysis for Victoria

Combined MFB and CFA data for the Melbourne and Melbourne East regions

Both the MFB and the CFA provided coverage in the highly populated Melbourne and Melbourne East regions, although the coverage by each varies markedly between different statistical subdivisions (SSDs). The MFB was the sole provider of services for vegetation fires attended in Inner Melbourne, Moreland City and Boroondara City SSDs and attended the highest proportion of fires in more centrally located SSDs of Western Melbourne, Northern Middle and Northern Outer Melbourne, Eastern Middle Melbourne, Southern Melbourne and Hume City. Fires in more distal locations increasingly fell under the CFA's jurisdiction. The CFA was sole or principal provider of services in the South Eastern Melbourne, Yarra Ranges Shire, Greater Dandenong City, and Melton–Wyndham, and Eastern Outer Melbourne SSD, but also attended 29 percent of fires in the Hume City SSD and 35 percent of fires in the Northern Outer SSD for the 1999–2000 to 2001–02 period. Overall, there were 109 postcodes for which the MFB was the sole attendee in the Melbourne and Melbourne East regions, but 53 instances where both the CFA and MFB attended fires in the same postcode. The net result is that neither the MFB nor the CFA provided a complete overview of total fire frequencies in the Melbourne–Melbourne East regions.

Based on the combined data for 1999–2000 to 2001–02, 40 percent of all fires in Victoria (excludes DSE data) occurred in the Melbourne region, with a further five percent occurring in the Melbourne East region. The greatest number of vegetation fires occurred in the Western Melbourne SSD, followed by Hume City, Northern Outer Melbourne, Northern Middle Melbourne and Melton–Wyndham SSDs (Figure 87). A comparatively low incidence of vegetation fires occurred in eastern and southern Melbourne (as indicated by the MFB data alone) but the total number of vegetation fires in these areas was higher than in the inner SSDs of Moreland City, Boroondara City and Inner Melbourne areas.

Fundamental difficulties occurred when trying to integrate the MFB and CFA data due to considerable differences in the proportion of deliberate vegetation fires each agency identified within the same area; for example, differences of 10 percent to greater than 40 percent occurred in individual SSDs (Figure 87). Some legitimate reasons exist as to why this might occur. In many instances, the number of vegetation fires one agency attended was markedly smaller than that attended by the other, and therefore may be unrepresentative of fires causes overall. Local differences in the rates of deliberately lit fires may also occur because the CFA and MFB cover distinctly different areas and potentially different types of environments within the same SSD.

These disparities were more evident at the postcode level. Rarely, did both the CFA and MFB attend a large number of fires in the same postcode. Rates of deliberate fires based on a small number of incidents are likely to be less accurate. Hence, greater differences are evident in the proportion of deliberate vegetation fires at a postcode level (Figure 88).

However, it is clear that the CFA consistently documented higher percentages of deliberate fires than did the MFB at a SSD level. Large discrepancies occurred in the Eastern Outer Melbourne region; even though the numbers of vegetation fires were more evenly distributed between the two agencies in this area there was a 44 percent difference in the estimated rate of deliberate fires. The implication from CFA data is that although the overall number of vegetation fires in the Eastern Outer Melbourne and Greater Dandenong SSD was comparatively low (compared with Western Melbourne or Hume SSDs) these areas recorded among the highest rates of deliberate fires (greater than 50%) in the Melbourne–Melbourne East regions. Clearly, that the MFB data does not reflected this alone, would in part be due to low fire frequencies. However, both agencies support low rates of deliberate fires in the Yarra Ranges Shire.

One of the principal differences between the CFA and MFB trends in Figure 87 and Figure 88 lies in the number and proportion of vegetation fires attributed to smoking-related causes (Figure 89). Notably, smoking-related causes accounted for 31 percent of fires the MFB attended from 1999–2000 to 2001–02, but only 2.1 percent of CFA-attended fires were classified as smoking-related, based on the variables available for this analysis. Hence, the number of smoking-related fires classified from the ignition factor will inherently be lower than that indicated in the 'form of heat of ignition' variable.

Part of the difference between the CFA and MFB data may pertain to the different methodologies used to derive the number of smoking-related fires for these two agencies. Notably, the number of smoking-related fires for the MFB was derived from the heat of ignition variable (AIRS codes 300 to 390), whereas the number of CFA smoking-related fires were derived from the ignition factor (abandoned and discarded materials) variable. Fires classified as smoking-related within the heat of ignition variable may have been assigned a number of different codes in the ignition factor variable, including incendiary and suspicious.

However, differences in methodology are unlikely to be the complete explanation for differences in the number of CFA and MFB smoking-related fires. Notably, just over 80 percent of all MFB smoking-related fires (based on the form of heat of ignition) were classified within the abandoned and discarded materials category. That is, the difference in methodology is only likely to account for 20 percent of the difference in the number of smoking-related fires, unless the CFA adopted a radically different approach to coding smoking-related fires, which is unlikely. Only five percent of MFB smoking-related fires were classified as deliberate; 92 percent were non-deliberate.

The other potential difference between the CFA and MFB data lay in the proportion of non-deliberate child fires. Non-deliberate child fires comprised 15.5 percent of all fires the MFB attended, but just 1.6 percent of vegetation fires the CFA attended. The classification adopted for child fires could potentially heavily influence this analysis. According to the AIRS manual, if the intention was malicious (regardless of age) the ignition factor should be recorded as incendiary or suspicious, or else child fires are classified independently within the ignition factor variable under the appropriate age classification. In this analysis, these fires are classified as accidental. The assignation of intent is complex in relation to children, being dependent not only on the age and maturity levels of the child, but also on the personal biases of individuals recording the fire cause. It may even be influenced by organisational policies (this is not specifically implicated for the MFB and CFA; see below).

The MFB and CFA recognise the potential difficulties posed by jurisdictional boundaries and seek to address those differences. For example, the CFA works closely with both DSE and MFB, and with other agencies such as Victoria Police, at all levels. There are provisions for joint investigation, improved interagency cooperation, better information sharing and interchangeability of data.

General comment about jurisdictional boundaries (all fire agencies): Urban expansion leads to demographic changes that influence not only the propensity for but also the predominant causes of vegetation fires within a region. Areas that may have once been rural or regional becomes incorporated in the greater metropolitan region. The net result is that without an adjustment to jurisdictional boundaries, two different agencies may be responsible for neighbouring suburbs within what may currently represent a continuous urban mass. This does not take into account the jurisdictional boundaries that already exist between land management (for state forests and national parks) and other fire agencies. Although there may be genuine differences between the rates of smoking-related and deliberate fires in neighbouring CFA and MFB regions (it is impossible to determine from this analysis), the above discussion shows that it is possible for marked differences in causal attributions to occur across jurisdictional boundaries.

Inherent uncertainties existed in determining the cause of a vegetation fire. In the majority of cases, no formal investigation of vegetation fires was undertaken, with assessment of the cause of a fire being dependent on the attending fire officer's best estimate. In light of the difficulty in assigning fire causes, the varying skills of attending officers, the available investigative resources, and the inherent flexibility of the AIRS database, it is highly possible that any two officers attending the same fire would attribute a different causal factor or code that information in a different way. It is also likely that differences existed at an organisational level, such as procedural differences (policy and implementation, both formal and informal), the extent and types of training provided to fire officers, the resources available to the organisation for fire investigation etc., which would generate across-agency differences in causal attributions.

A hypothetical example of what this might look like for child fires is as follows. The AFAC guide to classification of child fires is:

> If the intent was malicious, regardless of the age, the ignition factor should be recorded as incendiary or suspicious according to the circumstances. As an example, children playing with matches who accidentally start a fire in a house would be recorded here. If however, they had taken matches and set fire to grass with the intention of initiating an uncontrolled fire, the ignition factor would be recorded as incendiary.

Rarely would a child be caught in the act of lighting a fire and the exact intention of the child be elucidated. One agency might take the line: 'well we don't really know what the intention was, so the incendiary and suspicious categories are reserved for cases where there is very good evidence that the intention was malicious'. The advantage of taking this approach is that a large amount of information about the incidence and age of child fires is retained, information that would be lost within the database itself if those fires were simply classified as incendiary or suspicious. The agency could then use this information to direct when, where and how often to undertake fire awareness campaigns with children. On the hand, an agency might take the view that if a child takes matches to open grassland and proceeds to set it on fire, the intention was clearly to generate an uncontrolled fire, in which case it would direct its officers to classify those fires as incendiary or suspicious unless there were strong evidence that such fires were the result of play. Both approaches would fall within the AFAC guidelines but yield highly different results with regard to the incidence of suspicious and incendiary fires. The greater the incidence of child fires, the greater the discrepancy that may result between agencies.

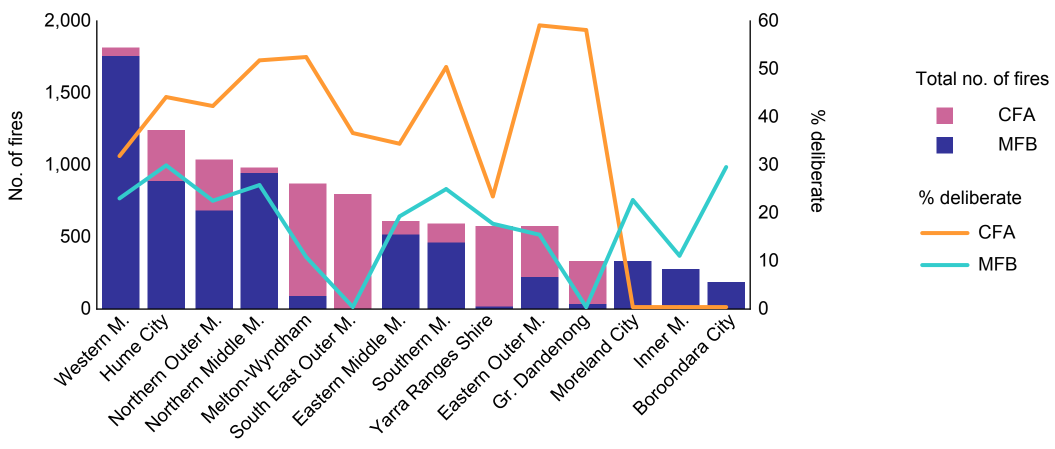
Jurisdictional boundaries pose limitations for fire agencies that do not exist for the general population, for the societal issues that may contribute to higher incidences of deliberate fires, or to the individuals who light fires. There are a number of levels at which jurisdictional boundaries may pose difficulties for fire agencies including, in the detection of fires, in the investigation of fires, and in the implementation of appropriate arson prevention strategies. The issue of detection is most central to themes of this report.

Jurisdictional boundaries potentially result in an incomplete knowledge of the incidence of vegetation fires (all causes) within a particular area. Temporal and spatial distributions of fires at a local level provide valuable insight about the cause of fires and the social patterns surrounding deliberately lit vegetation fires. When fires occur across jurisdictional boundaries, it is inherently more difficult to identify those patterns. Effectively, one agency may be unaware of how many fires another agency attended in the same area, or their distribution. Individually the number of fires may not seem large, but when the data are combined, the actual extent of the problem may be revealed.

Jurisdictional boundaries also potentially result an incomplete knowledge of the principal cause of vegetation fires within a particular area. Although both agencies may be aware of a high incidence there may be vastly different perceptions about the relative importance of different causes. It is not difficult to envisage, from the CFA and MFB analysis outlined above, that one agency may have considered deliberate fires to have been particularly problematic in a given area, while the agency in a neighbouring area may have regarded the rates of deliberate fires to be comparatively low. Similarly, differing perceptions may arise about smoking-related fires and child fires, among other causes. There may be a flow-on effect to policies fire agencies adopt with regard to fire management in those areas, and to the level with which it is deemed necessary to implement arson reduction strategies (note: this is a hypothetical example and is not intimated for either the CFA or the MFB).

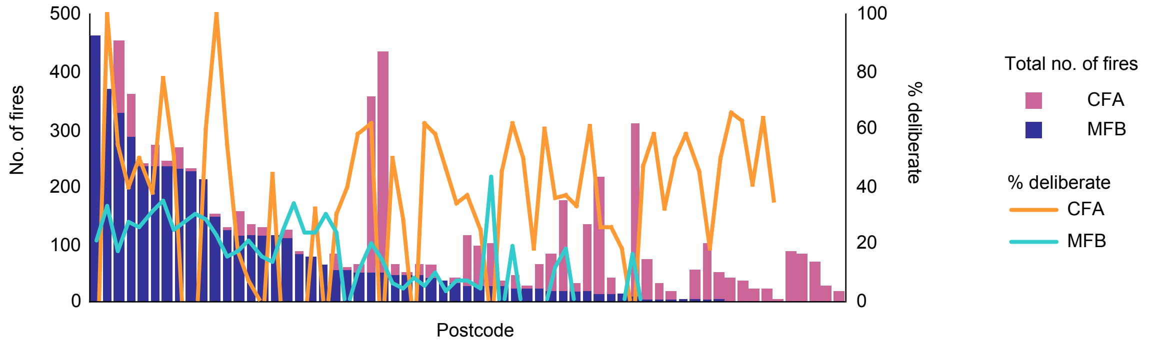
Given that police are also critical to the investigation and prosecution of offenders, local, regional, and state and territory boundaries in police services may also provide an added level of complexity over and above the jurisdictional boundaries that exist within the fires services. This is not to say that such problems would not exist in a single agency. In a single agency differences that manifest between officers or at a local (station) or regional level would be imbedded within datasets, that is they would exist but would be inherently more difficult to identify. Addressing the issue of arson prevention at all levels – detection, investigation and arson reduction – requires extensive liaison and information sharing within and between fire agencies, and police agencies, both at management and operational levels.

Figure 87: Number of vegetation fires and percentage deliberate fires, by fire agency, in each SSD; 1999–2000 and 2001–02



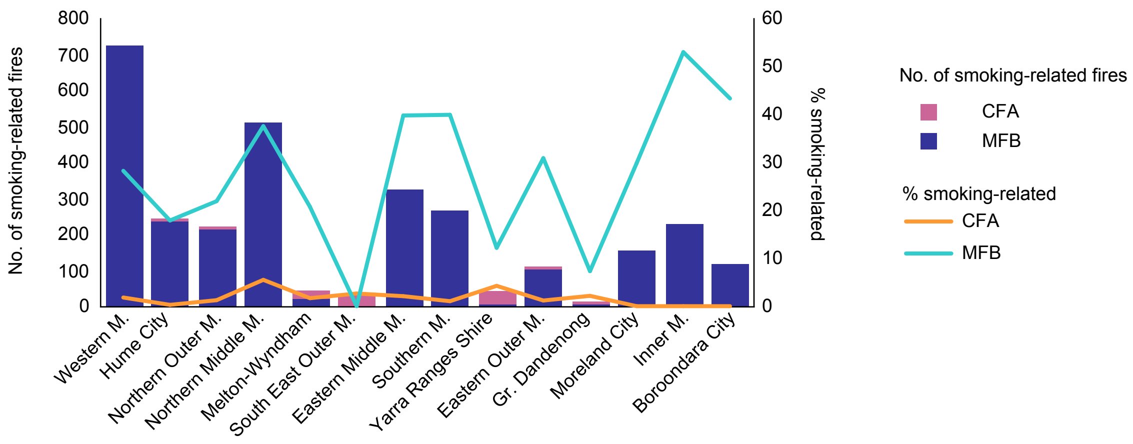
Source: CFA 1999–2000 to 2001–02 [computer file] and MFB 1999–2000 to 2001–02 [computer file]

Figure 88: Number of vegetation fires and percentage deliberate fires, by fire agency, in each postcode; 1999–2000 and 2001–02



Source: CFA 1999–2000 to 2001–02 [computer file] and MFB 1999–2000 to 2001–02 [computer file]

Figure 89: Number and percentage of smoking-related fires, by fire agency and by SSD, 1999–2000 and 2001–02



Source: CFA 1999–2000 to 2001–02 [computer file] and MFB 1999–2000 to 2001–02 [computer file]

MFB and CFA – Population analysis for Victoria

All vegetation fires: A distinct association exists between high fire frequencies and high population densities. That such a relationship exists is supported by the general increase in total number of vegetation fires with increasing population within each postcode, although the actual rates were highly variable within a population of a given size, with distinct differences occurring between regional and metropolitan areas (Figure 90). Commonly, postcodes in metropolitan Melbourne recorded a lower number of vegetation fires per person than regional postcodes with an equivalent population, at all but the greatest fire frequencies.

The recorded rates of vegetation fires within individual Victorian postcodes varied between one and 1,000 fires per 10,000 people per year. Nevertheless, it is evident that when population is taken into account, the total number of fires per 10,000 people per year decreased with increasing postcode population (Figure 91). The slope of this line and the actual values recorded at lower population densities is likely to have been affected by the short observation period. A single vegetation fire determines the lower limit in a single year (base rate). As the population increases, the base rate determined by a single fire event will necessarily decrease. Overall, the trend observed in regional Victorian postcodes with less than 5,000 people parallels the base rate slope. A short observation period has a greater impact on postcodes with a small population.

Twenty-eight Victorian postcodes recorded no vegetation fires in a three-year period. Postcodes in the Melbourne region typically recorded between one and 60 vegetation fires per 10,000 people per year. In outer metropolitan and regional areas, typical values decrease from 10 to 100 vegetation fires per 10,000 people per year for postcodes with a population of 1,000, to seven to 60 vegetation fires per 10,000 people per year for postcode with more than 10,000 people, overlapping with the higher end of the range observed for Melbourne postcodes.

Deliberate vegetation fires

The rates of deliberate fires per 10,000 people per year were also highly variable for Victorian postcodes. Typical rates ranging between 0.3 and 55 deliberate vegetation fires per 10,000 people per year.

Again, the minimum rate was determined by one deliberate fire in one postcode in a three-year period, and again the short observation period may lead to higher rates of deliberate vegetation fires per 10,000 people per year for very small communities. The maximum recorded rates of deliberate fires per person per year (20 to 30 deliberate fires per 10,000 people per year) remained comparatively uniform across a broad population range for postcodes with more than 1,000 people.

As observed for vegetation fires, the base rate as governed by one deliberate fire in three years decreased with increasing population. However, there was a critical population beyond which the minimum rates began to increase again. For regional Victoria this point occurred at approximately 5,000 people, whereas in the Melbourne region the value was over 10,000, attesting to the generally low rates of deliberate vegetation fires recorded for most Melbourne postcodes on a per-person basis. It is worth reiterating, that differences between the causal attributions for the CFA and MFB data discussed above may be important in generating the differences observed between the rates of deliberate vegetation fires on a per-person basis between the Melbourne and other outer metropolitan and regional areas.

Postcodes that recorded both high populations and high rates of deliberate vegetation fires per person per year have a large impact on the total vegetation fire frequencies in the state. Such postcodes were particularly evident in the Melbourne, Geelong, Bendigo–Loddon, Peninsula regions, and to a lesser extent the Ballarat region. Based on the combined CFA and MFB data, the eight postcodes that recorded in excess of 100 deliberate fires in three years accounted for eight percent of all deliberate vegetation fires (Table 5). The 20 postcodes that recorded 50 to 99 deliberate vegetation fires, and the 56 postcodes where 20 to 49 deliberate vegetation fires occurred (in three years), accounted for 16 and 23 percent of all deliberate fires in the state, respectively. One-quarter of all postcodes recording a fire, did not record a deliberate fire, and over half of the postcodes (N=268) recording a deliberate fire experienced less than five deliberate fires in three years. Collectively, postcodes recording less than five deliberate fires in three years were responsible for one-quarter of all deliberate fires in Victoria (excluding DSE fires). On average, the percentage of fires that were deliberate in a particular postcode decreased as the total number of deliberate fires in that postcode decreased. That is, on average a higher proportion of fires were deliberate in postcodes that recorded the highest number of deliberate fires (Table 5).

Although many Melbourne postcodes recorded low rates of deliberate fires per person per year, they commonly had a higher percentage of deliberate fires when compared with other areas with comparable rates of deliberate fires per person (Figure 92). This is despite the differences between the MFB and CFA data. Other fire causes played a more important role in regional Victoria.

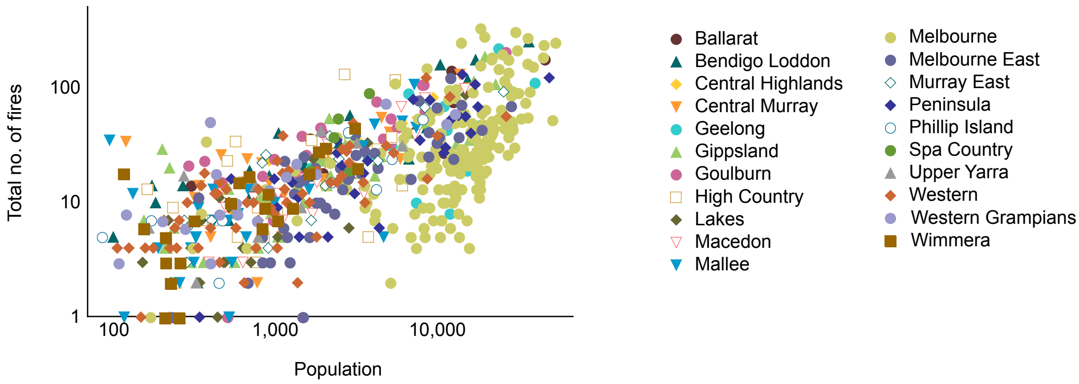
Comment: Using population corrected data enables some perspective when comparing fire frequencies across vastly different regions, but some understanding of the statistical limitations is needed. It can be particularly useful to identify those areas where deliberate fires may have been more problematic than otherwise suggested by the data. For example, the Spa Country region recorded only 304 vegetation fires in the five-year period, with 30 percent of fires being deliberate. However, it is evident from Figure 92 that three postcodes, with approximately 5,000 people, had comparatively high rates of deliberate fires per person. Typically, 40 percent of fires in those postcodes resulted from deliberate causes.

Table 5: Total number of postcodes with vegetation fires and deliberate fire frequencies within the specific ranges; CFA and MFB data combined; 1999–2000 to 2001–02

Postcodes with deliberate fires	Number of postcodes	No. of deliberate fires	Total no. of fires (all causes)	% of fires in these postcodes that were deliberate	Proportion of all deliberate fires in Victoria
>99	8	1,033	1,773	58.3	8.2
50–99	20	1,386	3,355	41.3	15.6
20–49	56	1,791	4,957	36.1	23.0
10–19	80	1,092	3,647	30.1	16.9
5–9	81	541	2,389	22.6	11.1
<5	268	561	5,431	13	25.2
Total	512	6,404	21,552	29.7	100.0

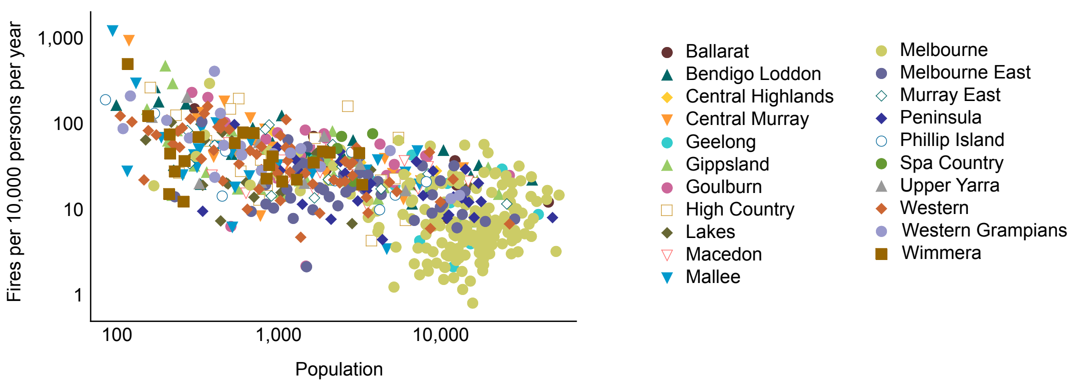
Source: CFA 1999–2000 to 2001–02 [computer file] and MFB 1999–2000 to 2001–02 [computer file]

Figure 90: Vegetation fires and population, by postcode and by region (number)



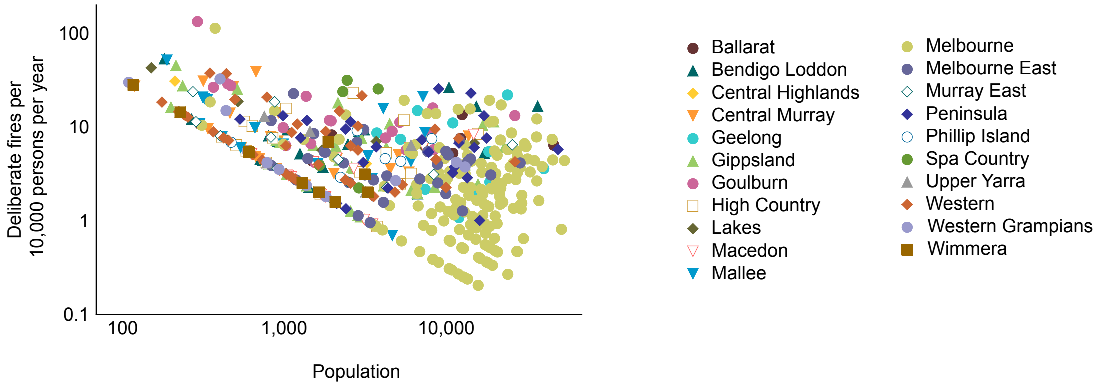
Source: CFA 1999–2000 to 2001–02 [computer file]; MFB 1999–2000 to 2001–02 [computer file]; ABS 2004. Population by post office area, 2001 [computer file]

Figure 91: Fires per 10,000 people, for individual postcodes within each region (number)



Source: CFA 1999–2000 to 2001–02 [computer file] and MFB 1999–2000 to 2001–02 [computer file]

Figure 92: Deliberate fires per 10,000 people, for individual postcodes within each region (number)



Source: CFA 1999–2000 to 2001–02 [computer file]; MFB 1999–2000 to 2001–02 [computer file]; ABS 2004. Population by post office area, 2001 [computer file]

Department of Sustainability and the Environment

Background information about the DSE dataset and its analysis

Important information about the Department of Sustainability and the Environment (DSE) dataset and the methodology employed to analyse it is outlined below:

- The data were sourced from the Victorian Department of Sustainability and the Environment (DSE).
- The database does not use AIRS classification codes.
- The dataset principally included vegetation fires; the database included 85 domestic rubbish fires and 31 industrial rubbish fires, although it is unclear if these fires were contained rubbish fires or subsequently spread to nearby vegetation. Similarly, not all fires that occurred in motor vehicles spread to surrounding vegetation.
- The DSE analysis is based on all fires within the DSE database, and although the term vegetation fires is used in this report to describe all DSE fires, a small number of fires may not genuinely have been vegetation fires.
- The analysis includes data from 1993–94 to 2003–04; the analysis is consistent with (that is, uses the same causal classification) and locally draws on data presented in Davies (1997) analysis of 1976–77 to 1995–96 DSE fire data in order provide a overview of long-term variations in bushfire activity.
- The cause is defined based on the ‘cause’ variable.
- Deliberate vegetation fires pertain to all vegetation fires classified as ‘deliberate lighting (malicious)’ and ‘burning vehicle, machine’. In order to be consistent with the analyses presented for other agencies, the term incendiary is used in all instance of the seven-fold causal classification scheme (that is, accidental, incendiary, suspicious, natural, reignition/prescribed burn/exposure, other and unknown), but the term deliberate is used in the non-deliberate versus deliberate classification scheme. The term deliberate is retained for instances where the causal category used Davies’ Fire Management Branch (FMB) classification. However, it is only use of the terms that changes as deliberate (FMB) = incendiary = deliberate in all instances.
- All natural fires were the result of lightning.
- Smoking-related vegetation fires were classified on the basis of:
  Cause = ‘Pipe, cigarette, match’. All smoking-related fires were considered accidental.

- The DSE defines an independent variable for the agent responsible for the fire. Hence, vegetation fires started by children in this analysis included all instances where a child was considered or identified as being responsible for the fire, and may be categorised as either accidental (non-deliberate) or incendiary (deliberate).
- The 'region' classification scheme used for the DSE analysis is based on DSE regions, and hence, are not consistent with the regions defined for the CFA or MFB data.
- Data does include area burned.

For more detail about these methodologies see the methodology chapter.

Note: Although causal information pertaining to the analysis may have stated with certainty, for example, '32 percent of DSE vegetation fires were deliberate', there was, in fact, considerable uncertainty about the actual number and proportion of fires that arose from a specific cause. Moreover, changes in other variables, such as the level of fire investigation training, can generate apparent trends that do not reflect actual changes in the cause of vegetation fires.

Overview

Salient points about DSE fires are summarised as:

- The DSE attended 8,355 fires from 1991–92 to 2003–04. The average number of fires attended was 641 fires per year (sd=212), but actual fire numbers ranged between 247 in 1992–93 and 1,070 in 1997–98 (Figure 93). On average, the DSE attends nine percent of vegetation fires in Victoria each year (this does not take into account that the CFA may, depending on the size, location, and potential danger etc. also attend).
- The DSE attended fires both on the public lands that lay within its jurisdiction as well as fires on neighbouring lands where fires potentially posed a hazard for public lands. There may also have been instances were the DSE was called to assist the CFA and MFB. Hence, not all DSE-attended fires occurred in national parks or forestry reserves and, as indicated above, individual fires may appear in several agencies fire databases.
- Approximately four million hectares was burned in the interval from 1976–77 to 2003–04; the vast majority was burned in 1982–83 and 2002–03. Deliberate fires were responsible for 0.5 percent of the total area burned.
- Deliberate causes were responsible for 31.8 percent of vegetation fires, which represented 35 percent of 'known' causes.

Cause

Almost one-third (32%) of DSE fires were classified incendiary (Figure 94). This was the single largest assigned cause of fires, comprising 35 percent of 'known' causes. Almost 28 percent of all fires during this interval were accidental in origin, with a further one-quarter of fires resulting from natural causes. Fires were assigned an unknown cause (includes missing data) in 9.4 percent of cases.

Specific ignition factors

FMB cause reflects the methodology Davies (1997) used in his analysis of DSE data for the period 1976–77 to 1995–96. This section is based on annual data from 1991–92 to 2003–04 (includes data from Davies 1997) and five-year averaged from 1976–77 to 2003–04. The last period from 2001–02 to 2005–06 was incomplete. Figures that draw on the percentage cause represent actual values calculated on the restricted data range, but frequencies were estimated for the five-year interval based on available frequencies over the restricted timeframe.

Notable finding can be summarised as:

- Both the annual data from 1991–92 to 2003–04 (Figure 95) and the five-year averages from 1976–77 to 2004–05 (incomplete; Figure 96) record an increase in the average number of deliberate fires over time, although the actual number tended to be somewhat variable from year to year.
- The number of natural fires started by lightning strikes was highly variable, with distinctly higher numbers of natural fires occurring in 1997–98, and to a lesser extent 2002–03. Heterogeneity also existed within the five-year averages. There was great potential for a single year, like 1997–98, to strongly affect the five-year average within which it lies.
- The number of fires recorded as escapes of campfires and barbecues increased slightly over the observation interval. This was evident both for five-year average data from 1976–77 to 2004–05 and the annual data from 1991–92 to 2003–04.
- Long-term, the numbers of fires resulting from escaped burn offs decreased. This was evident in the long-term, five-year average data but was not obvious in the annual data from 1991–92 onwards.
- There was a marked decrease in the number of smoking-related fires. This was evident from the early 1990s, being reflected in both the annual data and the five-year averages.

Although the number of deliberate fires has continued to increase since the mid 1970s, the proportion of deliberate fires has remained stable at 30 to 32 percent since the early 1990s (Figure 97). This compares with values of 18 to 21 percent for the period from the mid 1970s to the early 1990s.

There appears to be an antipathetic relationship between the proportion of deliberate and natural vegetation fires (Figure 97). In years with a higher frequency of lightning strikes, such causes typically account for a higher proportion of fires and hence deliberate cause comprises a lower proportion of all fires. This was particularly evident for 1997–98 and to a lesser extent 1998–99.

Based on five-year averages, the percentage of escaped burn offs (not departmental burns) and smoking-related fires decreased, and the proportion of escapes of recreational fires (campfire, barbecue) increased, over the extended observation period (Figure 98). These trends were less evident in the annual data (Figure 97).

Despite the dramatic increase in the proportion of deliberate fires in the early 1990s some caution is required before extrapolating these results longer-term, for example, by inferring that the rates of arson have dramatically increased in recent years. Potentially many factors affect data long-term; one of the most fundamental pertains to causal assignations.

In the early 1990s, the DSE implemented a training program covering fire investigation for a large number of their regional staff. It would be expected that as staff became more skilled at identifying the likely cause of a fire, in particular separating accidental and deliberate fires, there would be a marked shift in subsequent causal attributions. This is one possible explanation for the sudden shift in deliberate, but also other causes, in the early 1990s.

Smoking-related fires (including matches): Smoking-related fires are one category that may have been affected by the 1990s fire investigation training. The numbers of smoking-related fires (including matches) dropped from 55 to 60 fires per year in the mid eighties, to 10 to 15 fires per year since the mid 1990s (Figure 99). Although higher frequency were principally recorded in 1991–92, 1994–95 and 1996–97, the proportion of smoking-related fires has continued to decline, owing to increased numbers of fires of other causes. Smoking-related causes were considered responsible for starting 157 out of 7,482 (2.1%) of fires between 1993–94 and 2003–04.

Deliberate fires – burning vehicles: Approximately 18 percent of all deliberate lightings that occurred between 1993–94 and 2003–04 involved burning vehicles, with this cause comprising almost five percent of all fires attended by the DSE in Victoria. On average 30.5 vehicles were burned on public land in Victoria every year, ranging from seven in 1993–94 to 54 in 1997–98 (Figure 100). Burning vehicle fires comprised between six and 26 percent of deliberate fires in any given year, and have commonly accounted for five percent of all DSE-attended fires since 2000 (Figure 100). In many instances the vehicle fires did not spread to surrounding vegetation, but merely resulted in incineration of the vehicle. This does not, however, negate the potential danger that such fires posed to the environment.

Agent responsible for fire: Human beings were implicated in 43.8 percent of DSE-attended fires. This represents 64 percent of all cases when the agent responsible for the fire was 'identified'. People involved in recreational activities contributed to 9.8 percent of fires, residents 8.1 percent, farmers and graziers 7.2 percent, and children 6.5 percent (Figure 101).

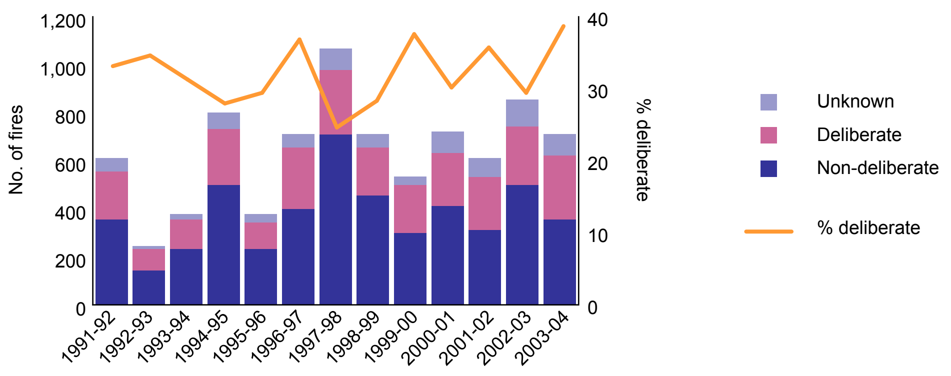
The causal attributions varied markedly between agent types. Not surprisingly, burn off escapes were the most important factor in fires attributed to government employees, farmers/graziers and residents, and escapes of campfires and barbecues were the principal causal category associated with recreationists (Figure 102).

The agent responsible for deliberate fires was unknown in 56 percent of cases from 1993–94 to 2003–04. Of those where the agent was known, the largest number were lit by children (n=340), 'other' agents (n=233), recreationists (n=151), residents (n=120), followed by farmers/graziers (n=108) and travellers (n=82).

Seventy percent of fires lit by children were classified as deliberately lit, with a further 13 percent of child fires being smoking-related (Figure 102). The causal attributions for travellers most closely approximated those observed for children; 57 percent of traveller fires were deliberately lit, with a further 11 percent being smoking-related. Approximately 40 percent of fires lit by 'other' agents and 20 percent of fires lit by recreationists, residents and farmers/graziers were classified as deliberate.

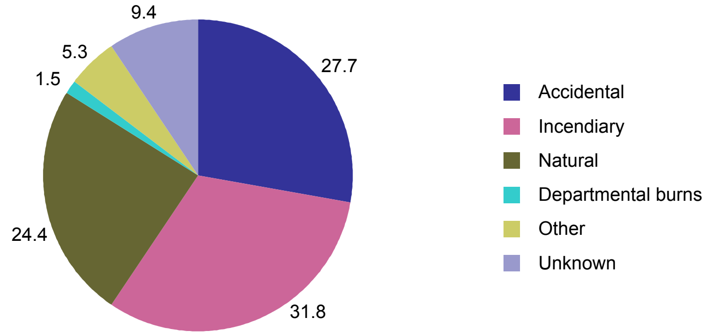
Recreationists were further classified into four categories, based on the activities that brought them into the regions where the fires started; namely, bushwalkers, campers, day visitors and fishermen. Most fires attributed to recreationists were started by campers (54%), followed by day visitors (27%), fishermen (17%) and bushwalkers (3.3%). Fires originating from the escape from campfires and barbecues were highest among campers and, to a lesser extent, fishermen (Figure 103). Day visitors lit the greatest number of deliberate fires (n=68), followed by campers (n=47) and fishermen (n=27). Although deliberate causes comprised a high proportion of fires started by bushwalkers (almost 40%), this group was only responsible for nine deliberate fires in 11 years.

Figure 93: Number and cause of vegetation fires each year



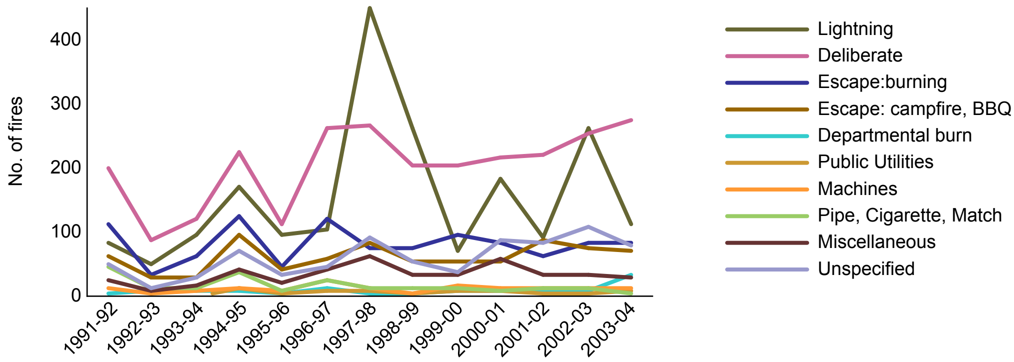
Source: DSE 1993–94 to 2003–04 [computer file]; Davies 1997

Figure 94: Fire cause, 1991–92 to 2003–04 (percent)



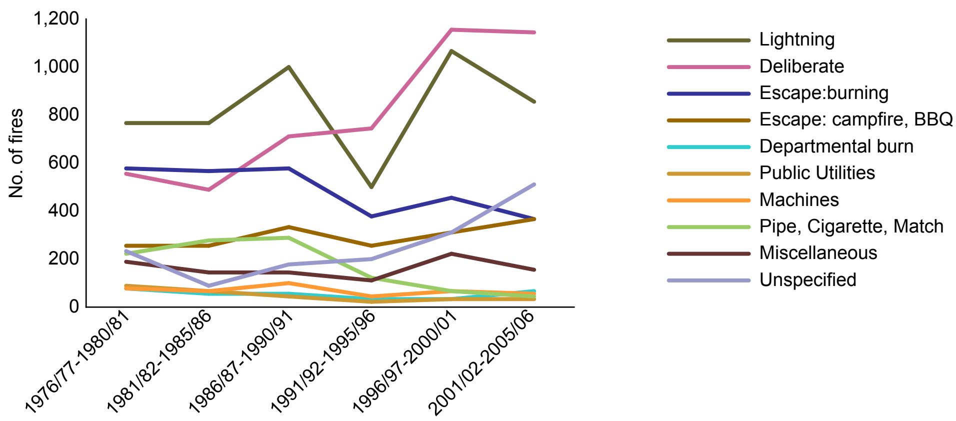
Source: DSE 1993–94 to 2003–04 [computer file], Davies 1997

Figure 95: FMB cause each year (number)



Source: DSE 1993–94 to 2003–04 [computer file], Davies 1997

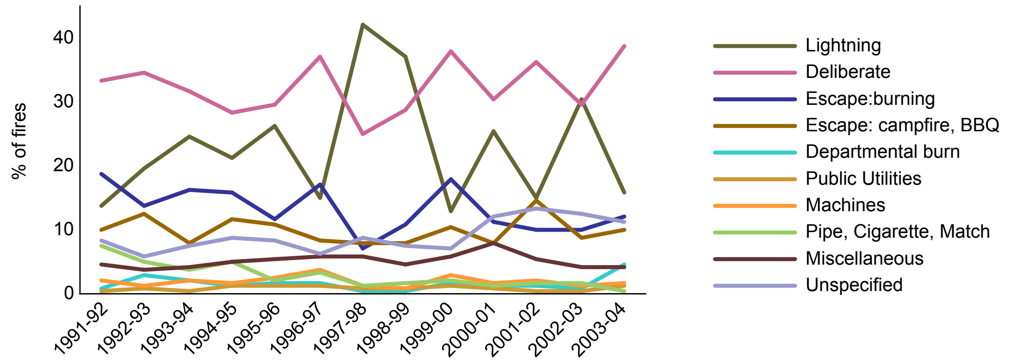
Figure 96: Five-year average of FMB cause (number)[a]



a: the number of fires in the 2001–02 to 2005–06 interval were estimated based on the frequencies and relative proportions of fires between 2001–02 until 31 January 2005

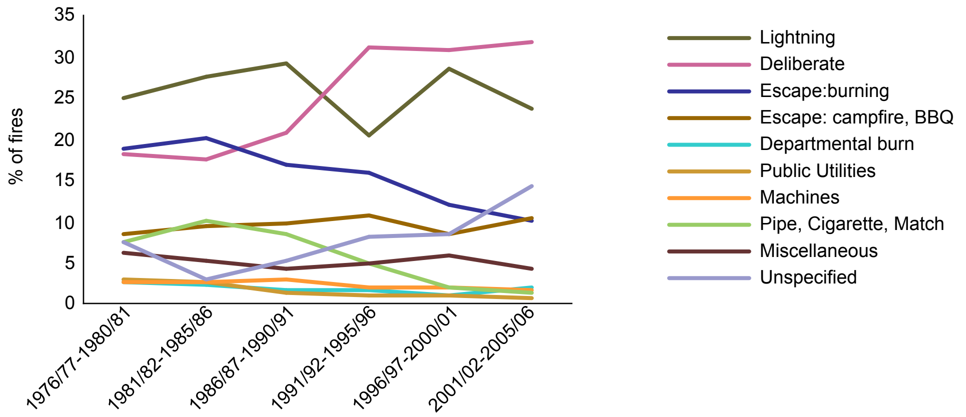
Source: DSE 1993–94 to 2003–04 [computer file]; Davies 1997

Figure 97: FMB cause each year (percent)



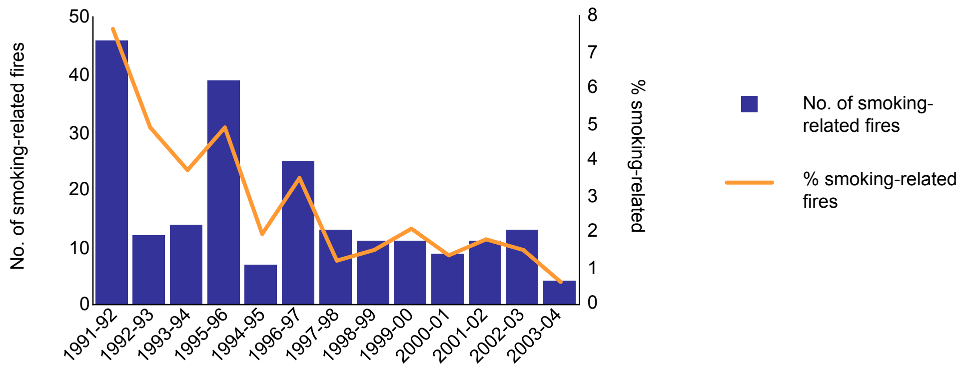
Source: DSE 1993–94 to 2003–04 [computer file], Davies 1997

Figure 98: Five-year[a] average of FMB cause (percent)



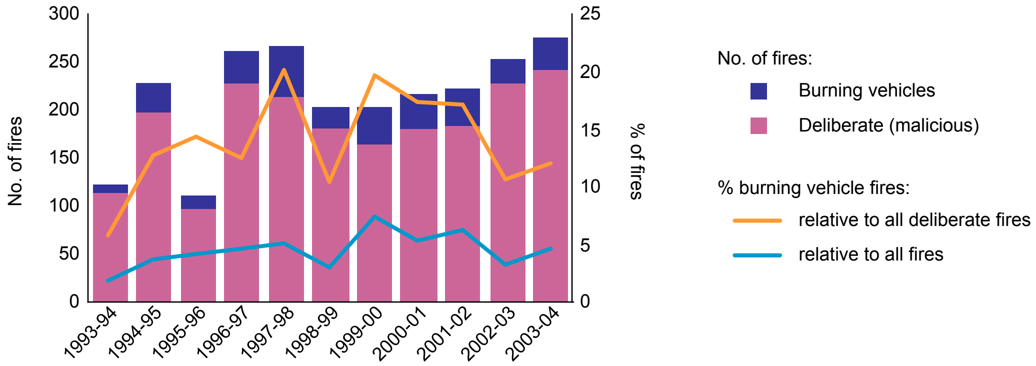
a: values for 2001–02 to 2005–06 are based on actual data for 2001–02 to 31 January 2005
Source: DSE 1993–94 to 2003–04 [computer file], Davies 1997

Figure 99: Number and percentage of smoking-related fires, by year



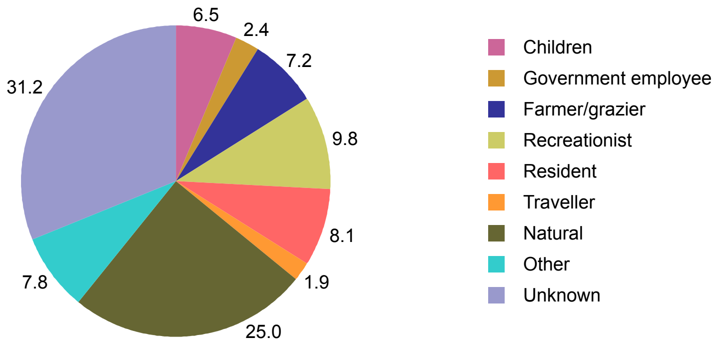
Source: DSE 1993–94 to 2003–04 [computer file], Davies 1997

Figure 100: Deliberate (malicious) fires and burning vehicle fires, by year



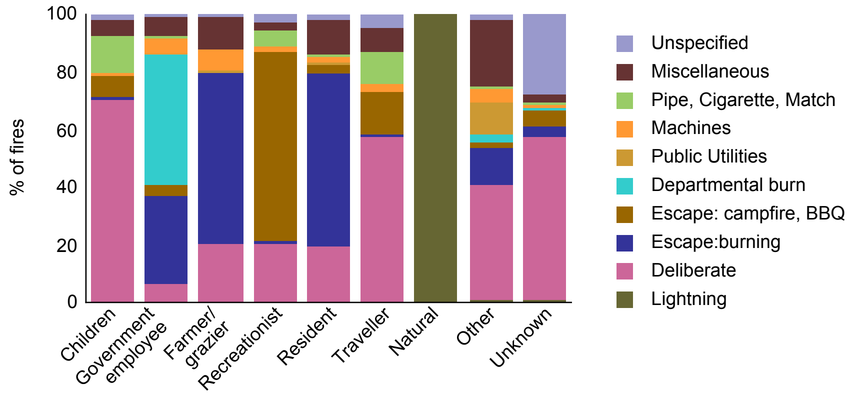
Source: DSE 1993–94 to 2003–04 [computer file]

Figure 101: Agents responsible for fire (percent)



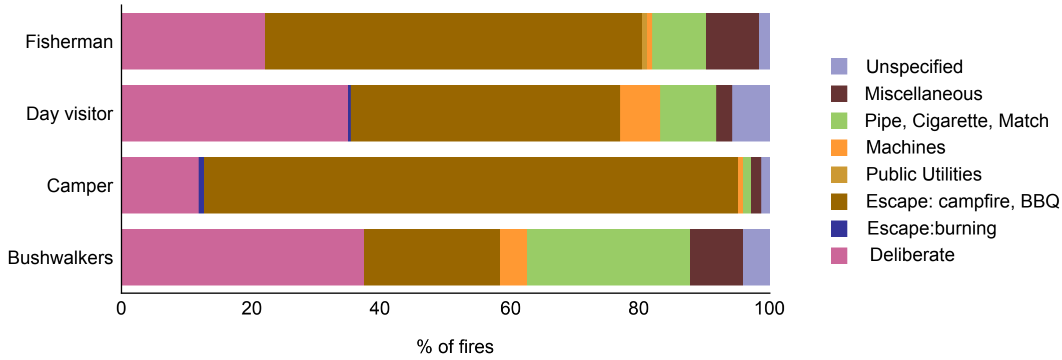
Source: DSE 1993–94 to 2003–04 [computer file]

Figure 102: Agent responsible for fire, by FMB cause (percent)



Source: DSE 1993–94 to 2003–04 [computer file]

Figure 103: Fires started by recreationists, by FMB cause (percent)



Source: DSE 1993–94 to 2003–04 [computer file]

Location

The location of DSE-attended fires was examined by region, including the regional distribution of fires of specific causes, and the agent responsible for fires, as well as the tenure of land on which the DSE attended fires.

Region and districts

The DSE defined five regions in Victoria, including the North East, North West, Gippsland, South West and Port Phillip (Figure 104). Vegetation fires were comparatively evenly distributed across all Victorian regions except the Port Phillip region, where the comparatively small number of fires reflected the small geographical extent of DSE tenure in that region. There were regional differences in the dominant cause and dominant agents responsible for vegetation fires in each region reflecting, among other variables, differing population distributions and land use practices. These are discussed below.

Cause

Regional differences in the cause of DSE fires for the period 1993–94 to 2003–04 are summarised as:

Deliberate fires: The greatest number of deliberate fires occurred in the North West (796 fires) and South West (705 fires) regions (Figure 105). Other regions recorded from 177 to 360 during the same interval. Deliberate fires comprised a high proportion of fires in both the North West and South West (42 to 44%), but also in the Port Phillip region (37%; Figure 106). The latter was intermediate between, but broadly consistent with, the values the CFA documented for the Melbourne (49% deliberate) and Melbourne East (25% deliberate) regions.

Natural fires: the greatest number and proportion of fires started by lightning occurred in the Gippsland (n=754; 43%), North East (n=449; 28%), and South West regions (n=428; 22%).

Escapes of burn offs: This a minor factor responsible for fires in all areas, typically accounting 13 to 15 percent of vegetation fires in each region. The exception was the North West where just eight percent of fires arose from this cause.

- **Recreational fires**: The greatest number of recreational fires occurred in the North East (248 fires), North West (217 fires) and to a lesser extent the South West (129 fires) regions (Figure 105). In these regions, recreational fires contributed to 16 percent, 12 percent and 6.8 percent of fires respectively (Figure 106).
- **Burning vehicles**: The greatest number of fires involving burning vehicles occurred in the South West, followed by the North East, and North West regions. Burning vehicles accounted for 17 to 18 percent of deliberate fires in the Port Phillip and South West regions, but only eight to nine percent of deliberate fires in the Gippsland and North West regions. In the North East region, such causes accounted for 28 percent of all deliberate fires. Roughly 10 vehicles have been burned on or near DSE lands in the North East every year since 1996–97.

Smoking-related fires: Between 16 (Port Phillip) and 44 (South West) smoking-related fires occurred in any one region over the observation period. Smoking-related fires comprised between 1.5 percent (Gippsland) and 3.9 percent (Port Phillip) of vegetation fires. That a higher proportion of smoking-related fires were reported for the Port Phillip region is not surprising given the high incidence of fires documented for the Melbourne region generally (see MFB analysis), and the comparatively lower contributions from natural causes. The Port Phillip region has the greatest population density of any DSE region, and reserves in close proximity to metropolitan Melbourne have high visitation rates.

Agent responsible for vegetation fires: Some caution is needed when drawing conclusions from regional variations in the causal agents responsible for fires owing to the greater body of unknown causal agents. Based on the available attributions, the following trends were ascertained:

- **Children**: The greatest numbers of fires were attributed to children in the North West (n=226) region followed by the South West (n=129) and North East (n=72) regions (Figure 107).

  In the North West, children were identified as being responsible for 12.4 percent of all fires in the region (Figure 108), and were the largest single identified causal agent, comprising 22 percent of cases where the causal agent was 'known'. Approximately 96 percent of all child fires in the North West region occurred within the Bendigo district, and principally within and around the city of Bendigo. The high number of fires started by children (indeed deliberate fires generally) around Bendigo reflects the extensive interface between the urban environment and the state forest, and other parks and reserves throughout the city and environs. Approximately 82 percent of child fires in the North West were deliberately lit, with a further 10 percent being smoking-related.

  Despite the high number, fires attributed to children comprised just 6.8 percent of all fires in the South West region. The greatest number of child fires in the region occurred in the districts of Bacchus Marsh (33% of child fires in the South West region), Ballarat (43%) and Horsham (16%). Although the majority (59%) was considered malicious, 18 percent resulted from escaped campfires and barbecues, and a further 15 percent were smoking-related.

  In the North East region, children were responsible for 4.5 percent of all fires. Approximately 54 percent of these are deliberately lit, with children accounting for at least 12 percent of all deliberate lightings in the North East region; this represents 22 percent of deliberate fires where the agent was 'known'. Twenty-two percent of child fires in the North East were smoking-related with a further 11 percent representing escapes from campfires and barbecues.

  Although the frequency was comparatively lower, children accounted for 9.6 percent of fires in the Port Phillip region, a finding that is consistent with observations from the MFB and CFA data. In contrast, only 1.4 percent of fires in the Gippsland region were attributed to children, with 10 of the 18 child fires in that region being considered deliberate.

- **Other agents**: Further summarised points about other causal agents are:

  In keeping with the causal data, recreationists were responsible for the greatest number of fires in the North East and North West regions (Figure 107); they were responsible for 21 percent of cases where the agent was known (Figure 108).

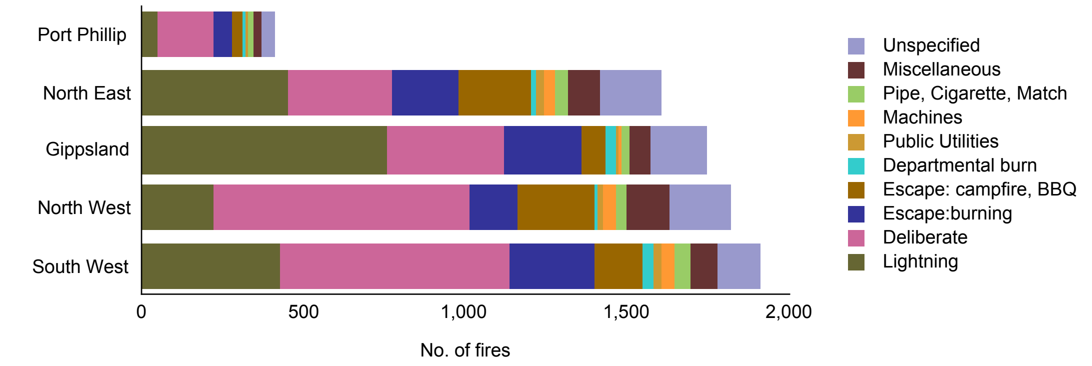
  Residents in all regions started similar proportions of fires. With the exception of the Port Phillip region, the proportion of all vegetation fires started by farmers/graziers was also comparable across regions.

  A refined examination of only the agents specifically responsible for deliberate fires in each region shows that children were responsible for a higher proportion of deliberate fires in those areas that recorded a high number of child fires generally (Figure 109). Recreationists were responsible for a high proportion of deliberate fires in the North East but not in the North West, despite both regions recording high numbers of fires started by recreationists. Similarly, residents contributed to a high proportion of deliberate fires in the Gippsland region. Farmers and graziers were responsible for the highest proportion of deliberate fires in the North East and Gippsland regions. There is, however, some uncertainty in these results as there were very high levels of unknown/unidentified causal agents for deliberate fires.

Figure 104: Map of DSE regions

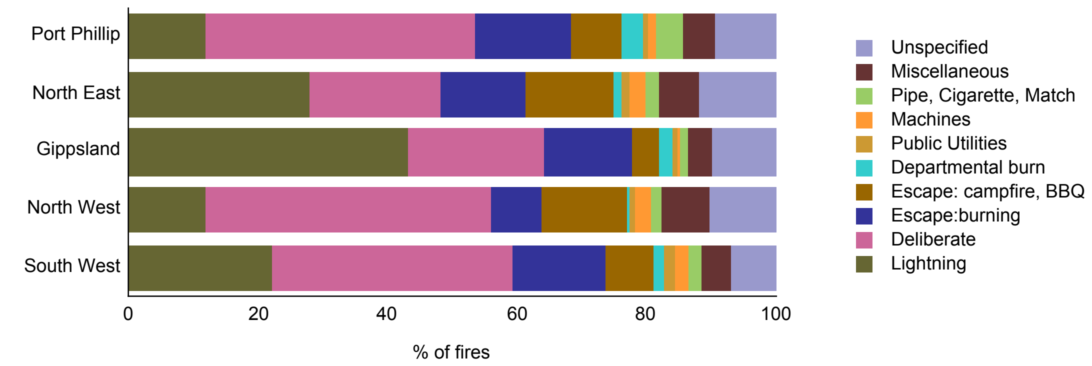
Source: DSE 2007a

Figure 105: Fire cause, by DSE region (number)



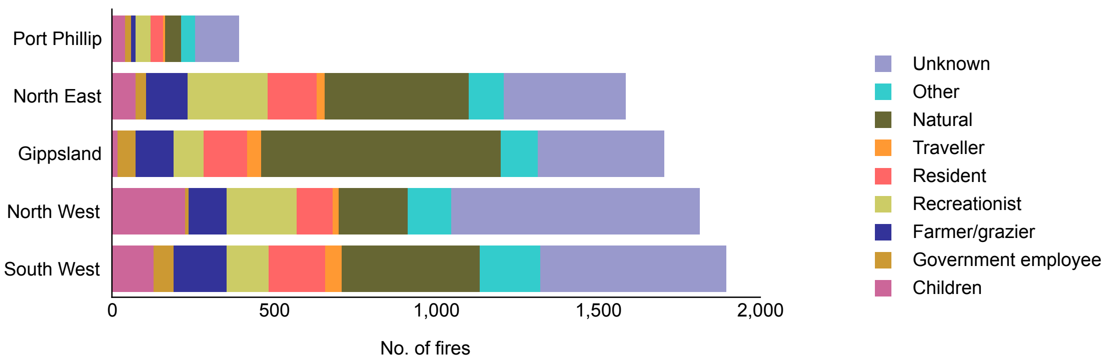
Source: DSE 1993–94 to 2003–04 [computer file]

Figure 106: Fire cause, by DSE region (percent)



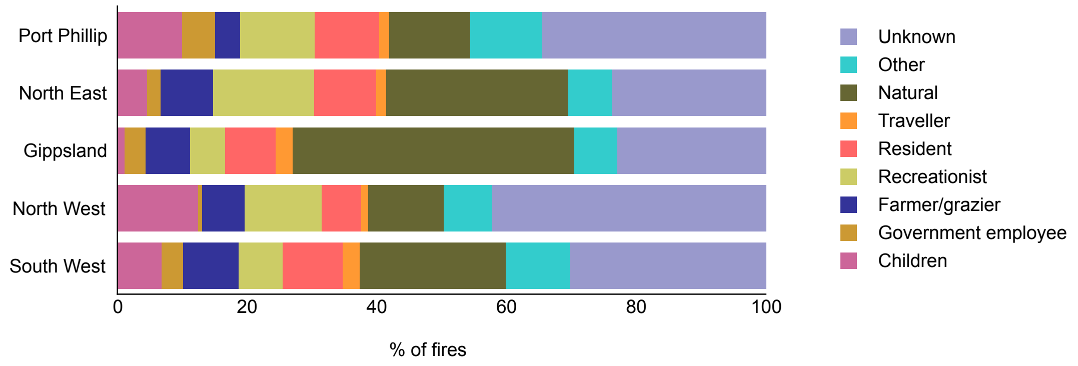
Source: DSE 1993–94 to 2003–04 [computer file]

Figure 107: Agent responsible for fire, by region (number)



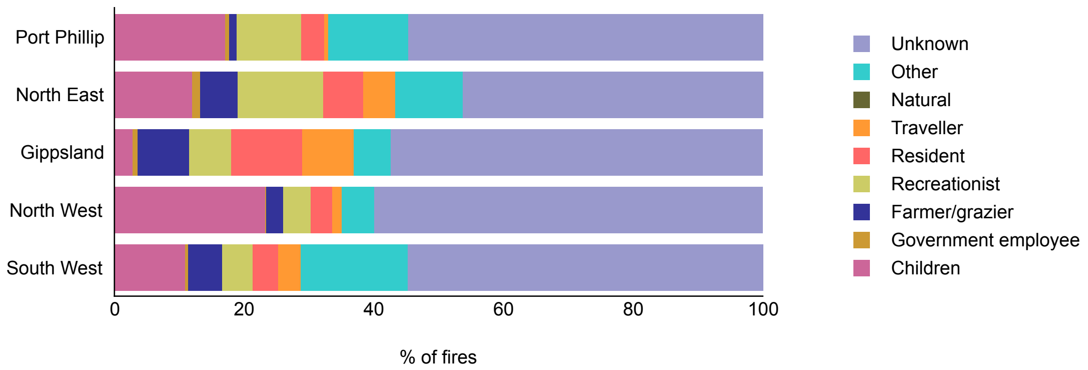
Source: DSE 1993–94 to 2003–04 [computer file]

Figure 108: Agent responsible for fire, by region (percent)



Source: DSE 1993–94 to 2003–04 [computer file]

Figure 109: Agent responsible for deliberate fires, by region (percent)



Source: DSE 1993–94 to 2003–04 [computer file]

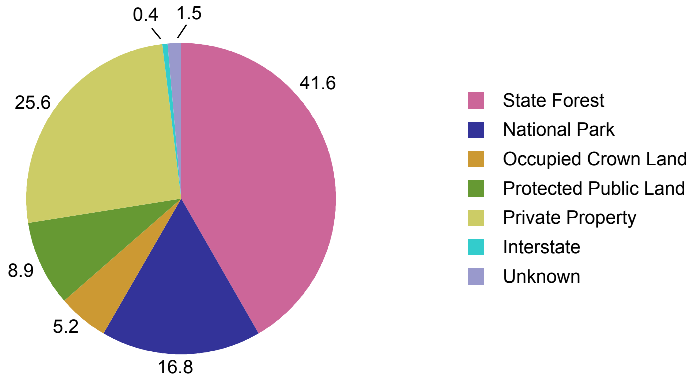
Tenure

It is emphasised the land tenure may have changed markedly over the last 20 years. The following analysis is based on statistics provided for fires since 1993–94.

Forty-two percent of DSE-attended fires occurred in state forests with 26 percent on private property and 17 percent in national parks (Figure 110). In state forests deliberate lightings outweighed natural fires 6:5 and collectively these two causes accounted for two-thirds of fires in this tenure (Figure 111). In contrast, natural fires were 1.5 times more frequent than deliberate lightings in national parks. Collectively, natural and deliberate causes accounted for three-quarters of all fires on that tenure. Approximately 43 to 44 percent of fires on unoccupied Crown land and protected public lands also resulted from deliberate causes.

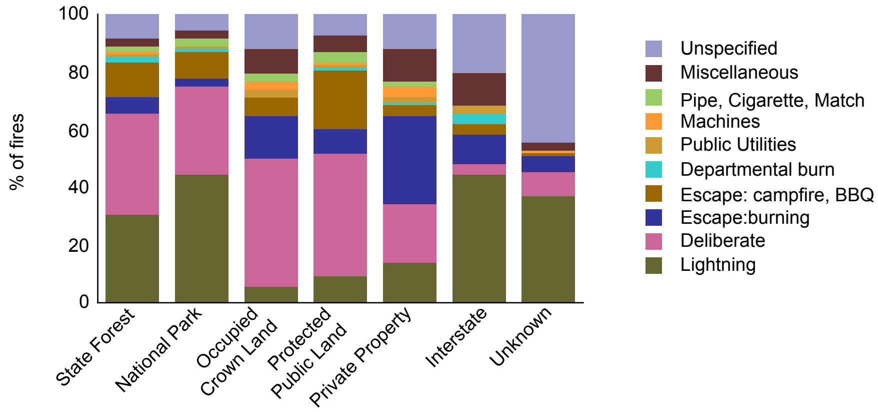
A high proportion of fires on private property resulted from the escape of burn offs (31%). However, 20 percent of the fires on private property were classified deliberate.

Figure 110: Land tenure on which fires occurred (percent)



Source: DSE 1993–94 to 2003–04 [computer file]

Figure 111: Land tenure on which fires occurred, by region



Source: DSE 1993–94 to 2003–04 [computer file]

Timing

The timing of fires was examined by week of the year and by day of the week.

Week of the Year

Most vegetation fires occurred between mid September and late April, with the greatest number of fires occurring in the weeks around Christmas–New Year. Nevertheless, the principal time that fires occurred varied between causes (Figure 112 and Figure 113). Natural fires typically occurred within a narrow interval that spanned end November to end February (Figure 112). Although, deliberate fires were more evenly distributed throughout the year, peak numbers coincided with the peak numbers in natural fire frequencies. Recreational fires (campfires and barbecues) were most common around Christmas–New Year and March–April, coinciding with Christmas and Easter holidays respectively (Figure 113).

Fires collectively described as burning off comprised fires lit for vegetation removal, burning for regeneration in areas where timber has been harvested, and fuel reduction burning for wildfire mitigation. The timing of burn offs may vary between these different activities, as there are fundamentally different objectives. Commonly, escaped burn offs in November and December related to fires that started on freehold land, but subsequently spread to public land. There was a large increase in the number of burn offs in November–December, immediately before seasonal fire restrictions (Figure 113). Similarly a large number of burn offs occurred in late March–April, when fire restrictions were removed.

The timing of the bushfire season and, hence, the dominant timing of DSE vegetation fires varied subtly between years (Figure 114):

- In 1997–98, 214 fires occurred during week 48 (early December), before the late December–early January maxima. Of these, 179 resulted from lightning strikes. The majority (n=132) occurred in the Gippsland region. Only one deliberately lit fire occurred in the Gippsland region during that week.
- In 2001, 166 fires occurred during week 1 of 2001. Of these 134 were natural. These fires primarily occurred in the Gippsland and South West regions although elevated numbers of fires occurred in the North East region. Only three deliberate fires were lit during this week.
- In 2002–03, several small spikes in fire activity in mid September and early November preceded the early January fires that subsequently burned 1,000,000 ha in the state's northeast. The spike in mid September resulted from a mixture of causes, although burning off stubble and grass, and deliberate fires featured most frequently. In contrast, 48 of the 68 fires in week 44 (early November) resulted from lightning. Seven deliberate fires were lit during this week.

There were strong parallels between the distribution of deliberate and child fires throughout the year. The greatest number of child fires occurred during late December–early January, with the number of child fires decreasing as the school holidays progressed (Figure 115). The number of child fires decreased in February, but subsequently increased in March. Presumably, this reflected increased numbers of fires during the Easter school holidays (the timing of which varies from year to year).

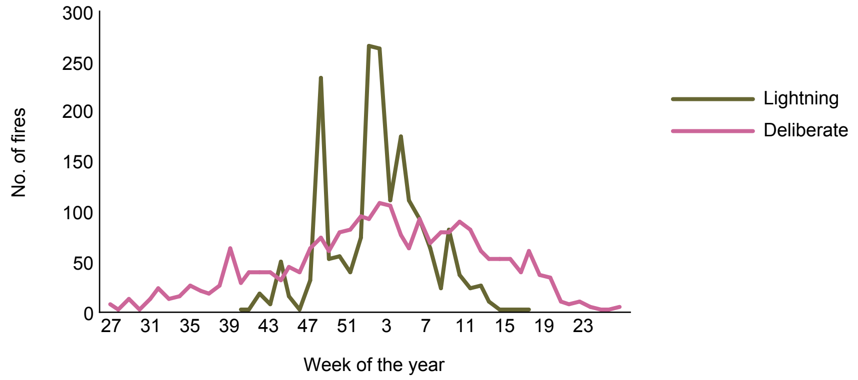
No substantial differences were evident between the timing of fires in different regions of Victoria.

Day of the week

No substantial or predictable differences were evident in the numbers of non-deliberate, deliberate and unknown fires that occurred on different days of the week (Figure 116). Nevertheless, trends were evident for specific groups. For example, recreationists lit 70 percent more fires on Saturday and Sunday than on the average weekday (Figure 117). Children lit about 30 percent more fires on Saturday than on the average weekday, with subtly higher fire numbers also occurring on Sundays and Mondays (Figure 117). The lack of distinctly higher numbers of child fires on weekends may be consistent with the observation that many child fires occurred during school holidays, but was not reflected in either the metropolitan or regional fire data.

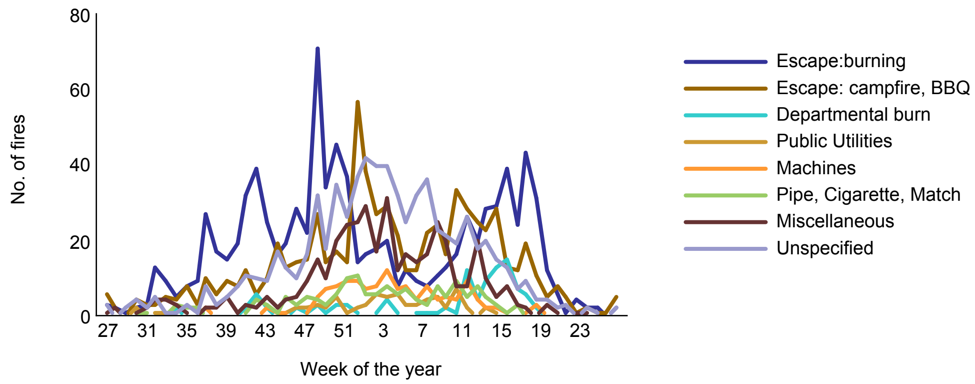
Overall, greater numbers of campfire/barbecue escapes occurred on Saturday, Sunday and Monday than on other days of the week (Figure 118). The number of deliberate fires was also greater on Sunday and Monday, but not on Saturday.

Figure 112: Natural and deliberate fires, by week of the year (number)



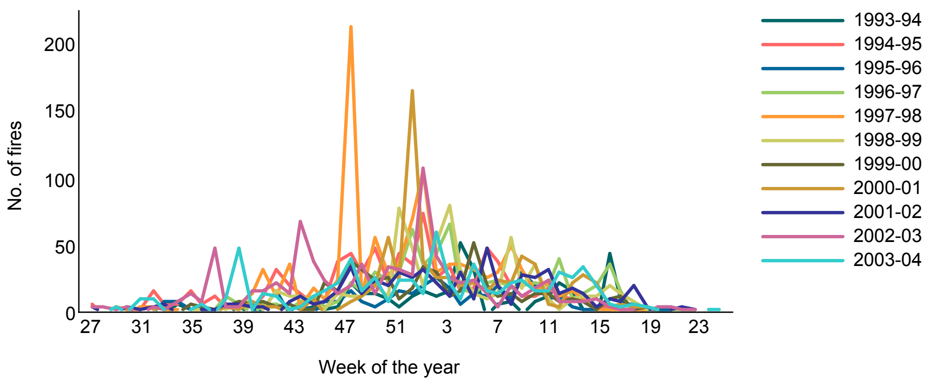
Source: DSE 1993–94 to 2003–04 [computer file]

Figure 113: week of the year fires occurred, by cause (number)



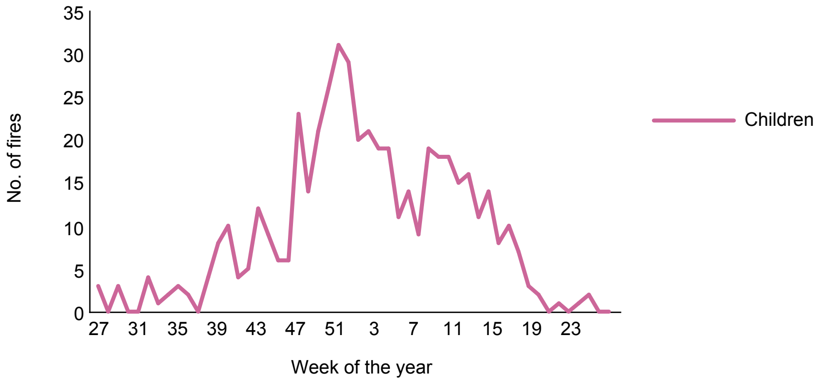
Source: DSE 1993–94 to 2003–04 [computer file]

Figure 114: The week of the year fires of all causes occurred, by year (number)



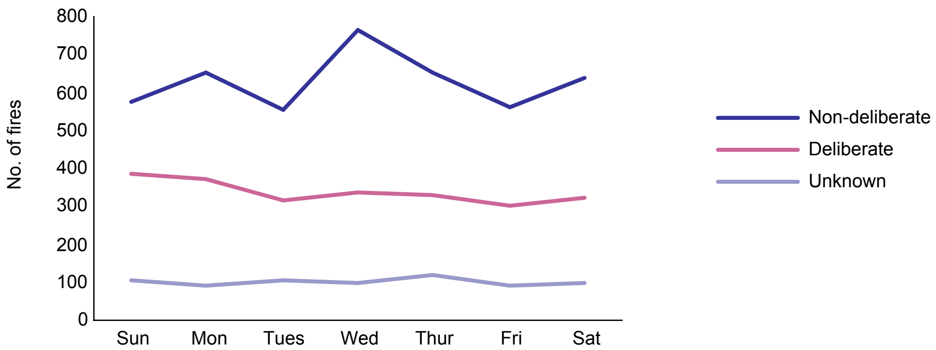
Source: DSE 1993–94 to 2003–04 [computer file]

Figure 115: Fires started by children, by week of the year (number)



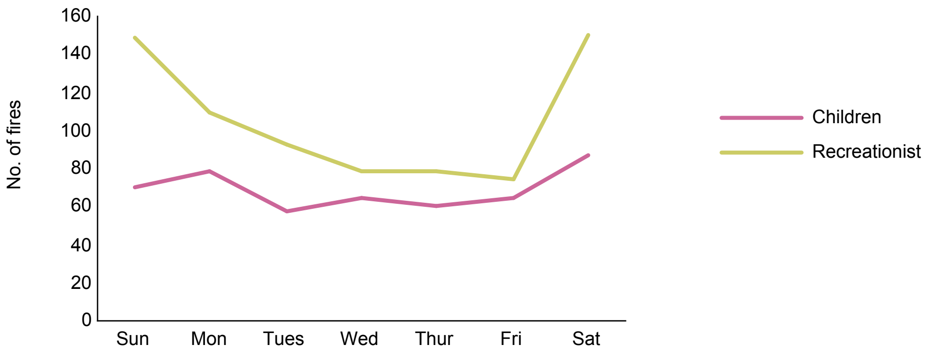
Source: DSE 1993–94 to 2003–04 [computer file]

Figure 116: Day fires occurred, by cause (number)



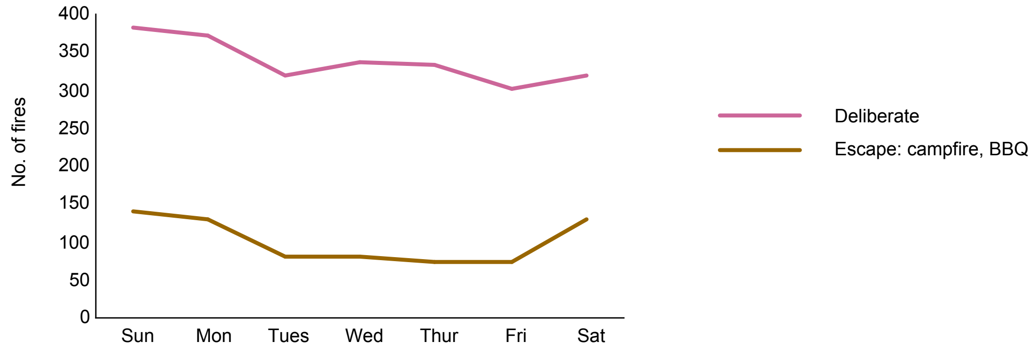
Source: DSE 1993–94 to 2003–04 [computer file]

Figure 117: Day fires occurred, for children and recreationists (number)



Source: DSE 1993–94 to 2003–04 [computer file]

Figure 118: Deliberate fires and escapes of campfires/barbecues, by day of the week (number)



Source: DSE 1993–94 to 2003–04 [computer file]

Area burned

The majority of fires the DSE attended were small; 59 percent were less than 1 ha and 86 percent were less than 10 ha. Overall, the number of fires decreased with increasing fire size, although as observed elsewhere there was a characteristic hump for the 10–49 and 100–500 ha categories (Figure 119). The distribution for area burned was similar across all years for fire size of fires less than 500 ha, but large events were restricted to specific years. These were generally years characterised by many large fires, not just one-off large fires, and were typically associated with drought.

The distribution of large fire events determines the total area burned in any one year. For example, fires of 10,000 ha were responsible for 86 percent of all land burned in DSE-attended fires during 1993–94 and 2003–04. Fires between 1,000 and 9,999 ha contributed to a further 8.7 percent. Fires less than 100 ha accounted for just 1.6 percent of the total area burned. Many factors may affect fire size. For example, given the same drought conditions and fire weather, fires that started in remote locations would result in larger fires, as it is more difficult to establish control lines as compared with fires that occurred in areas of higher population density where there are adequate road systems and more available suppression forces.

Although the number of fires decreased with increasing fire size for all causes (Figure 119), there were some differences in the distribution of fires based on cause (Figure 120):

- A high proportion of large fires were natural in origin. Lightning was the only cause of fires larger than 100,000 ha (n=2).
- Escapes of departmental burns tended to be moderately large in size. Almost half burned in excess of 10 ha, and 10 fires (9%) burned greater than 500 ha. The largest burned 28,800 ha in the North West of the state in 2001–02.
- Deliberate fires, overall, accounted for a decreasing proportion of fires with increasing area burned (Figure 120). Nevertheless, exceptions were noted. Sixteen deliberately lit fires burned 500 ha or more, and seven burned 1,000 ha or more. Four of those seven fires occurred in the South West region, but the two largest, which burned 6,100 and 5,149 ha, occurred in the North East region. Of those deliberate fires greater than 1,000 ha only one occurred during 2002–03, that is, during a particularly adverse year. Only two fires greater than 500 ha were deliberately lit during 2002–03.

- The proportion of fires resulting from escape of campfires or barbecues and smoking-related fires were primarily small, and such fires generally accounted for a decreasing proportion of fires in larger area categories. Nevertheless, some exceptions are noted. There were two cases where escapes from a campfire or barbeque resulted in more than 10,000 ha being burned. In 1994–95 one fire burned 10,050 ha in the South West region. The largest burned 32,000 ha in the Gippsland region during 1997–98. The largest smoking-related fire burned 2,310 ha in the North West region during 2000–01.

Approximately 1.7 million hectares were burned in total, in DSE-attended fires on and off public lands from 1993–94 to 2003–04. Fire statistics for the total area burned were necessarily dominated by large fire events during this period.

From 1993–94 to 2003–04, fires started by lightning strikes accounted for 92 percent of the total area burned in DSE-attended fires in Victoria (Figure 121). These figures are dominated by the 2002–03 statistics when a fire started by lightning burned 1,092,421 ha in the North East region. Another two fires started by lightning during the same year burned 181,400 ha and 31,530 ha in the North West and Gippsland regions respectively. These fires accounted for three-quarters of the total area burned in DSE fires between 1993–94 and 2003–04.

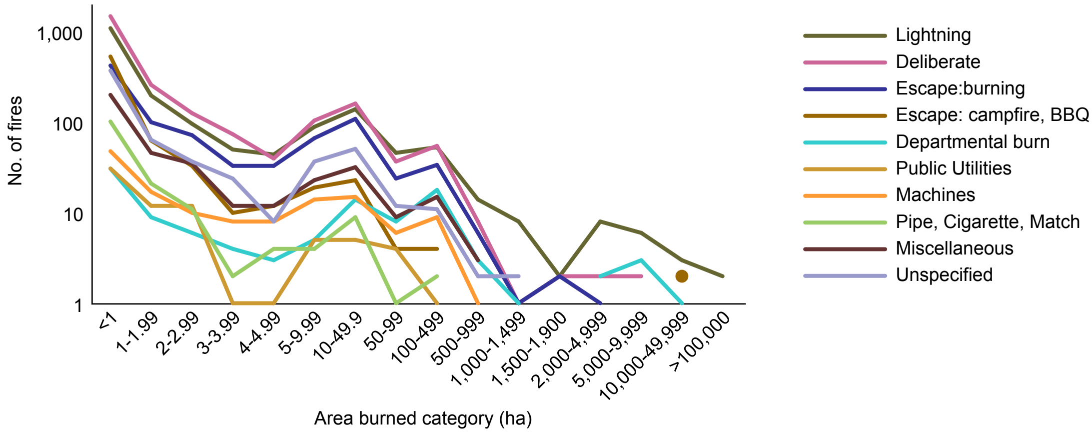
In the same period deliberate fires accounted for only 0.5 percent, escapes from campfires or barbecues 2.7 percent, and smoking-related fires just 0.2 percent of the total area burned. Escapes from campfires or barbecues actually contributed to the largest area burned by any human-related activity (2.7%; Figure 121) followed by departmental burns (2.4%), and escapes from burn offs (1.0%). For all causes, the proportion of the total area burned was dominated by largest fire events relating to each cause.

The amount of land burned in any one year was highly variable, ranging from 1,345,654 ha in 2002–03 to 14,170 ha in 1993–94. The total area burned and the principal causal attribution varied markedly between years, being determined the largest fire events in each particular year. No single cause was consistently responsible for the area burned; for example, natural fires were responsible for 82 to 98 percent of the total area burned in 1995–96, 1998–99 and 2002–03, but less than 36 percent in all other years, being between six and 20 percent in six of the 11 years (Figure 122). Escapes of campfires and barbecues accounted for a high proportion of the total area burned in 1994–95 and 1997–98. Departmental burns accounted for 39 to 65 percent of the total area burned in 1993–94, 1999–2000, 2001–02 and 2003–04 (most were contained on public lands), whereas burn offs accounted for the highest proportion of area burned (36 to 49%) in 2000–01 and 2003–04. Deliberate fires were commonly responsible for three to 16 percent of land burned in any one year, but in 1995–96 and 1999–2000 accounted for 40 and 28 percent of the area burned, respectively.

Using Davies' 1997 data, it is possible to evaluate longer-term variations in the total area burned. Approximately four million hectares was burned by DSE-attended fires from 1976–77 to 2003–04; the vast majority of this burned in 1982–83 and 2002–03, and to a lesser extent 1980–81, 1984–85 and 1990–91 (Figure 123). It is possible, from the five-year averages, to examine variations in the cause of the total area burned over time (Figure 124). Fires resulting from public utilities, burn offs, departmental burns and other miscellaneous causes burned greater areas in the first half of the observation period than in the latter half. Overall, comparatively small areas were burned in any one year from the mid 1980s until 2002–03 when large areas were burned by natural fires. Excluding the two largest natural fires in 2002–03, the total area burned in that year was comparable to other years in the 1993–94 to 2003–04 interval. It is emphasised that a single fire event under adverse conditions can have a dramatic impact on area burned in any one period, and that caution is needed when extrapolating the presented data; that is, when inferring long-term trends based on these results.

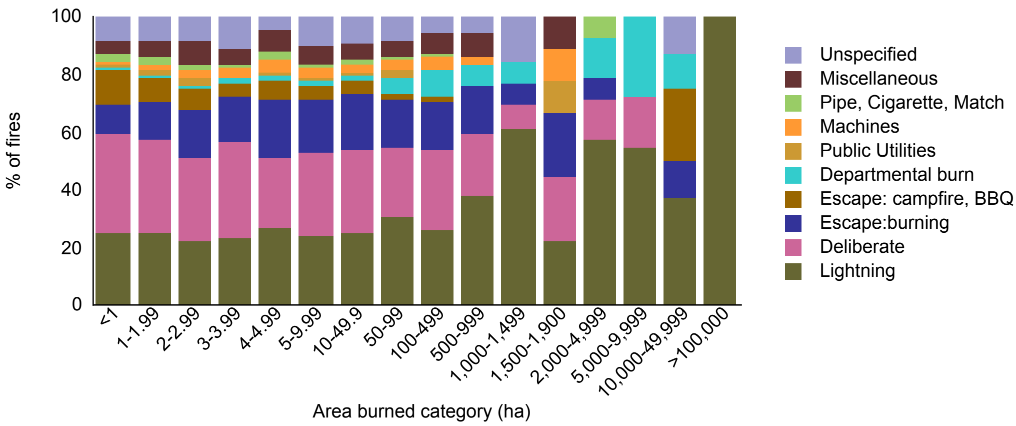
Although the number of deliberate fires increased from the mid 1970s to the mid 2000s, the total area burned by these fires has been substantially lower than in the mid 1970s to mid 1980s. With the exception of the 2001–02 to 2005–06 period, which was profoundly affected by the 2002–03 fires, deliberate fires were responsible for 10 to 15 percent of the total area burned within a five-year interval, irrespective of the total area burned (Figure 122).

Figure 119: Area burned category (ha), by FMB cause (number)



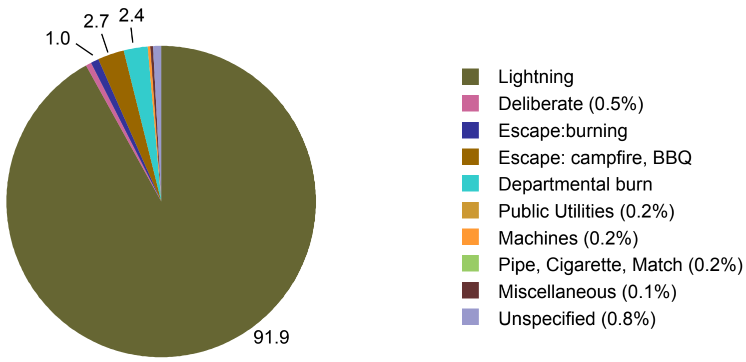
Source: DSE 1993–94 to 2003–04 [computer file]

Figure 120: Area burned category (ha), by FMB cause (percent)



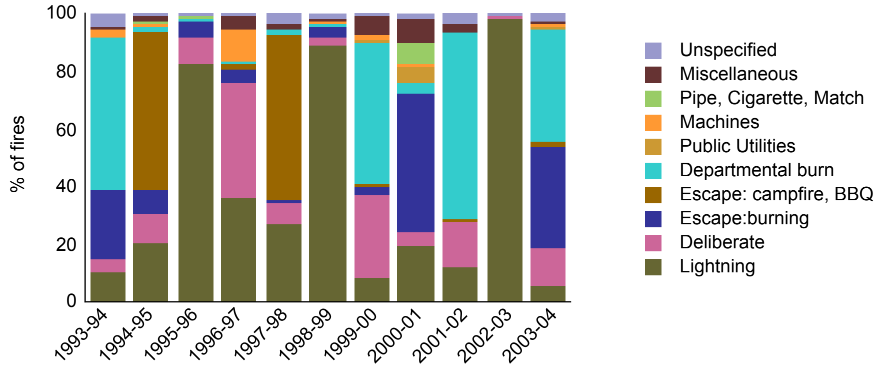
Source: DSE 1993–94 to 2003–04 [computer file]

Figure 121: Total area burned, by each FMB cause (percent)



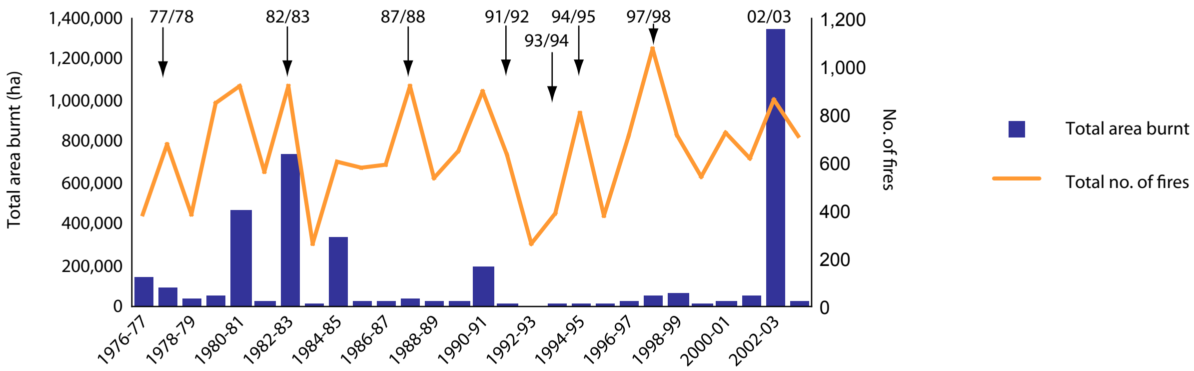
Source: DSE 1993–94 to 2003–04 [computer file]

Figure 122: Total area burned, by FMB cause, each year (percent)



Source: DSE 1993–94 to 2003–04 [computer file]

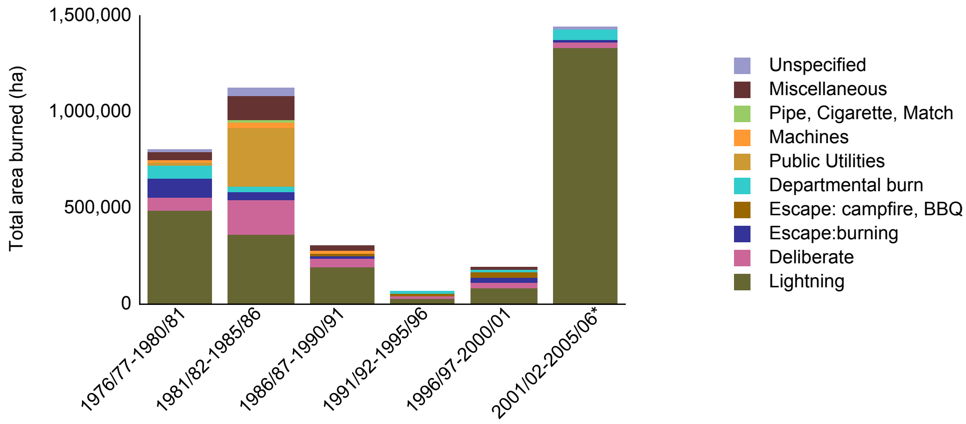
Figure 123: Number of fires and total area burned by vegetation fires each year from 1977–78 to 2003–04[a]



a: annotated numbers refers to years in which the average Southern Oscillation Index was less than –10, classified as an El Niño event by the Australian Bureau of Meteorology

Source: DSE 1993–94 to 2003–04 [computer file]; Davies 1997

Figure 124: Total area burned in five-year intervals for each FMB cause (number)



Source: DSE 1993–94 to 2003–04 [computer file]; Davies 1997

Cause and climate

Widespread drought in southeastern Australia commonly occurs during an El Niño cycle. During an El Niño event warmer air masses in the Pacific result in a slackening of easterly trade winds that would normally bring moist air over eastern Australia. The outboard movement of air masses from the Australia–Indonesia region towards central tropical regions, results in many parts of eastern and southern Australia experiencing conditions ranging from lower than normal rainfall to severe drought.

The Southern Oscillation Index (SOI), which measures relative differences in air pressure across the Pacific, provides a simple measure of these large-scale changes in climatic conditions that affect so many aspects of Australian life such as, the strong relationship between variations in SOI and wheat yield (Rimmington & Nicholls 1993). The link between SOI and rainfall across the country is strongest during winter and spring (June–November) in southern and eastern Australia. This may be problematic from a bushfire perspective as, during an El Niño cycle, hot dry summer conditions follow a dry winter and spring that leads to earlier curing of grasses, potentially profound drought, and generation of exceptionally adverse bushfire weather. The Australian Bureau of Meteorology typically classifies an El Niño event as one where the average SOI was less than –10.

This relationship between vegetation fires and an El Niño cycle are examined below. Of additional concern is whether the number of deliberate fires also increased during periods of adverse bushfire weather.

Number of fires: A number of mitigating factors negate the possibility of any one-to-one correlation between SOI and rainfall, or between rainfall and frequency and area burned. Such mitigating factors include variations in the number of fires started by each cause, which may or may not be governed by climatic factors, and the presence of more localised weather conditions that are more distantly related to global climatic conditions. Human actions also have a bearing on these relationships, including factors that impinge upon the capacity of firefighting resources to suppress fires (such as location or access), variations in the preventative measures enacted before fires occur, and previous fire and growth histories that govern available fuel resources, etc.

Overall, the DSE attended a greater number of fires during years associated with El Niño events, than in years not associated with El Niño events (Figure 125). On average, the DSE attended 780 fires in years associated with El Niño events from 1991–92 to 2003–04 as compared with an average of 589 in years not associated with El Niño events. Even greater disparities become evident when the number of fires during an El Niño event is compared with those recorded in neighbouring years. On average 490 fires occurred in years that occurred before or after an El Niño event.

Nevertheless, there were exceptions. High fire numbers occurred in years where there was no associated El Niño event, for example in 1979–80, 1980–81 and 1990–91. There were several months of very low rainfall in either spring or summer in all three years. Conversely, not all El Niño events were associated with high numbers of fires, for example, 1993–94. This reflects the fact that at El Niño event is unique; both the extent and distribution of drought effects varies even though comparable values of the SOI may be observed.

Lightning fires: The difference between the number of fires occurring during years associated with an El Niño event and other years is almost entirely due to greater numbers of fires started by lightning. There was an average of 212 lightning fires in El Niño years compared with 122 in non-El Niño years, representing an increase of 74 percent. Overall, there was an exponential relationship between the number of fires documented as having started from lightning strikes and the total number of fires the DSE attended in a given year (Figure 126). That is, as the number of lightning strikes increased, natural fires accounted for an increasing proportion of fires that occurred during that year. The greatest number of fires resulting from lightning strikes recorded from 1991–92 to 2003–04 occurred in 1994–95, 1997–98 and 2002–03 all of which were associated with El Niño events. However, negative SOI in the early 1990s were not associated with an increased number of fires started by lightning strikes.

Lightning fires during El Niño events

A number of difficulties present when attempting to document and interpret statistics on fires started by lightning. Not all lightning strikes are observed or suppressed, as those occurring in remoter areas may be extinguished naturally under all but the most adverse weather conditions, and not all fires resulting from lightning strikes may be identified as such. An increased number of fires started by lightning do not necessarily reflect an increase in the amount of lightning per se. Drier conditions and a lack of precipitation associated with electrical storm activity increases the probability that resultant natural ignitions are not dowsed by rainfall.

Deliberate fires: Overall, a strong linear relationship existed between the number of deliberate fires and total number of fires in a given year (r=.88; p<.001; Figure 127). Hence, the total number of deliberate fires also tended to be greatest in years characterised by higher numbers of fires overall, which given the above was commonly years associated with greater numbers of lightning strikes. Nevertheless, the increase was, on average, comparatively minor. Only eight percent more fires were lit during years associated with an El Niño event than in other years. Moreover, the number of deliberate fires in 1996–97 was comparable to that in 1997–98 and the number of deliberate fires in 2003–04 was greater than in 2002–03.

Although comparatively high numbers of deliberate fires occurred in 1994–95, 1997–98 and 2002–03, there was no consistent agent responsible for this increase. Data show that no single group was responsible for higher numbers of deliberate fires during particularly adverse years, hence:

- Virtually every agent group, except farmers, recorded a greater number of fires during the 1994–95 El Niño event compared with bracketing years.
- No single group was characterised by a peak in 1997–98, with respect to neighbouring years, yet collectively they combined to yield a peak in the total fire frequency during this year.
- During 2002–03, ‘other causes’ and travellers were the only groups to experience a noticeable peak, but increased numbers of residents conducted deliberate fire setting relative to the previous year. This was particularly evident for the North East region. The numbers of fires started by children were comparative low in 2002–03 when compared with much of the 1990s, a statistic that coincides with comparatively low numbers of child fires in the Bendigo region in that year.

Other causes: On average, greater numbers of fires of other causes occurred during El Niño events, including escaped burn offs (23% higher), and escaped campfires and barbecues (20% higher). Greater numbers of smoking-related fires were also documented but this primary occurred in the early 1990s. No differences were evident later in the observation period. There was a comparatively poor correlation between the number of accidental fires and the total number of fires in a given year (r=.66; p<.05).

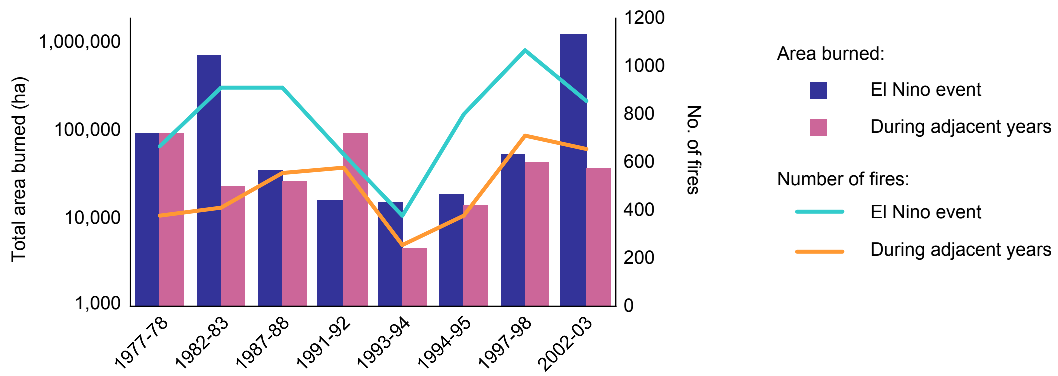
Area burned: A similar but less rigorous relationship existed between the total area burned and El Niño events. The largest total area burned in fires in Victoria during the observation period occurred in 1982–83 and 2002–03. Both were associated with severe drought conditions facilitated by El Niño events. Similar arguments could be raised in relation to 2006–07.

Nevertheless, large tracts of land were also burned during 1980–81, 1984–85 and 1990–91 which were not associated with a strongly negative SOI. As noted above, the relationship between the area burned in fires and weather is complex, and some caution should be exercised when interpreting temporal data. Commensurate changes in bushfire management, preparedness, and suppression have likely affected the total area burned during subsequent bushfires. It may therefore not be valid to compare the total area burned in the early 1980s with that burned in this century, as an indicator of bushfire severity. It is evident from Figure 125 that the total area burned in any one year on or near public lands in Victoria has remained low since the early to mid 1980s, and that 2002–03 was an anomaly. That is, effective fire management enabled fires to be controlled and suppressed during most El Niño events. It was only in 2002–03, when fires burned in inaccessible terrain in the northeast, under adverse weather conditions, and high levels of drought that large areas of land were burned.

In summary, there appears to be close relationship between vegetation fires and El Niño events in Victoria. The relationship between the two is not correlative or predictive; rather it is one of probabilities. There is a greater probability that fire agencies will attend natural fires during El Niño events. There is also a greater probability that bushfire agencies will need to intensify their efforts during more adverse bushfire weather. Not all El Niño events will lead to disastrous consequences, as the intensity has to reach a certain threshold in order to exceed the capabilities and resources afforded by fire services and management. The continued elimination of preventable causes (such as fires pertaining to public utilities) and good fire management and suppression practices will effectively mean that large areas of land will be burned only under conditions where widespread and highly adverse bushfire conditions exist (as evidenced for 1982–83 and 2002–03).

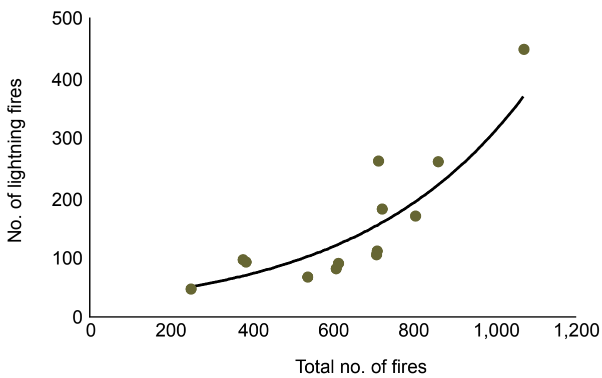
There is a greater probability that widespread drought will arise during an El Niño event. That such a relationship is comparatively strong for public lands in Victoria is consistent with the observation that the link between SOI and rainfall is strongest during the winter and spring periods in southeastern Australia, and that Victoria relies on that winter–spring rainfall to mitigate against early curing before the hot dry summer.

Figure 125: Number of fires and area burned in El Niño events, as compared with neighbouring non-El Niño years



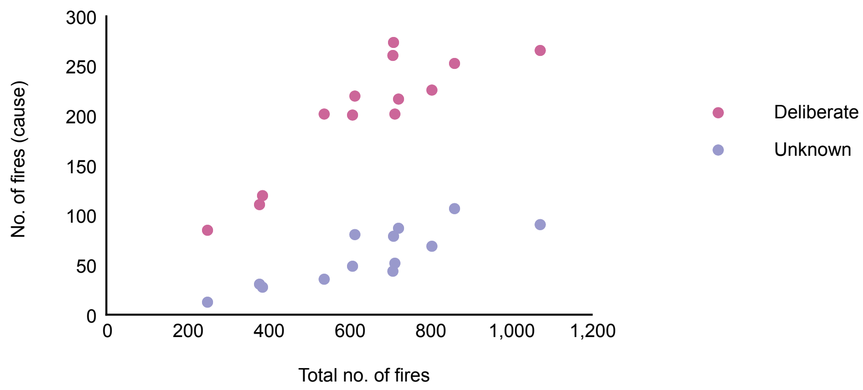
Source: DSE 1993–94 to 2003–04 [computer file]; Davies 1997

Figure 126: Natural fires and total vegetation fires each year (number)



Source: DSE 1993–94 to 2003–04 [computer file]; Davies 1997

Figure 127: Relationship between deliberate and total fires the DSE attended each year (number)



Source: DSE 1993–94 to 2003–04 [computer file]; Davies 1997

Summary

Number of vegetation fires: Australian Productivity Commission reports indicate there are typically between 5,800 and 8,000 landscape (vegetation) fires per year, with the average for 2001–01 to 2004–05 of 6,900 (this is marginally lower than the average of 7,700 calculated from the data used in the report), accounting for 28 to 33 percent of all fire incidents attended by Victorian fire services (APC 2006). With respect to individual agencies:

- **MFB** attended 9,543 fires from 1997–98 to 2001–02; accounting on average for one-quarter of all vegetation fires attended in Victoria each year; numbers attended each year were comparatively stable, with the highest number occurring in 2000–01.
- **CFA** attended 25,693 vegetation fires from 1999–2000 to 2003–04, accounting on average for two-thirds of all vegetation fires attended in Victoria each year; numbers attended each year were comparatively stable, with the highest number occurring in 2000–01 and 2002–03.
- **DSE**: 8,355 vegetation fires from 1991–92 to 2003–04; accounting on average for nine percent of all vegetation fires attended in Victoria each year; actual attendances ranged between 247 in 1992–93 and 1,070 in 1997–98.

Type of incident: The types of incident attended both within and across fires agencies, depending on the nature of the lands over which they had jurisdiction, is summarised as:

- **MFB**: Principally small fires in urban areas, but may include some bushfires. Specifically, 28 fires burned 10 ha or more, two burned between 1,500 and 2,000 ha, 63 percent were classified as small vegetation fires, 18 percent as grassfires, nine percent as mixed scrub, bush, grassfires, and nine percent as other vegetation/outside fires that were not classified or insufficient information to classify.
- **CFA**: Fires occurred in a range of environments from the outer suburbs of metropolitan Melbourne, in and around major regional centres, to rural and remote locations. As the CFA also helps the DSE fight fires on public lands, many fires may be duplicated across these two agencies. Hence, fires attended varied from small vegetation fires in urban environments to large bushfires, 31.5 percent were small vegetation fires, 46.1 percent were grass fires, 8.9 percent were scrub, bush, mixed grass fires, 11.5 percent other vegetation and other outside fires (not classified or insufficient information to classify), and 1.8 percent were forest or wood fires (greater than 1 ha).

The proportion of grassfires and mixed scrub, bush, and grass fires (with or without forest/wood fires [greater than 1 ha]) was relatively similar across regions. The proportion of deliberate fires was comparatively uniform across incident types, although deliberate fires accounted for a higher proportion of fires in nurseries/vineyards/orchards, and a lower proportion of grain/crop fires.

- **DSE**: The DSE principally attends fires in its jurisdiction (public lands, including state forests and conservation area), but approximately one-quarter all fires attended occurred on private property.

Cause of fires in Victoria are summarised in Table 6 and outlined in further detail below.

- **Deliberate fires** comprised 21 to 32 percent of all fires attended, and 31 to 41 percent of known causes, for individual agencies. On an agency-weighted basis, deliberate fires accounted for at 30 percent of all fires attended, representing 38 percent of known causes of vegetation fires in Victoria (Table 6). The proportion and number of deliberate fires the CFA and MFB attended remained comparatively stable over the five years analysed; the number and proportion of deliberate fires the DSE attended appears to have increased since the mid 1970s, although the proportion of deliberate fires has remained comparatively stable since the early 1990s (this figure may reflect improved fire investigation skills). Deliberate fires involving burning vehicles accounted for 15 percent of deliberate fires the DSE attended between 1993–94 and 2003–04.
- **Natural fires** accounted for 16 percent of all fires the DSE attended, but just 10 percent of fires the CFA attended and less than two percent of fires the MFB attended (Table 6); however, only 12 percent of fires the MFB attended and 46 percent of fires the CFA attended were definitively attributed to lightning, so actual rates of natural fires may be even lower for rural and urban brigades than has been stated.
- **Smoking-related fires**: proportions varied markedly between agencies, accounting for 31 percent of MFB fires, but just two percent of fires attended in regional areas. For the MFB, the number of smoking-related fires was significantly positively correlated with the total number of vegetation fires each year ($r=.94$; $p<.01$), and the total number of vegetation fires within each statistical subdivision (SSD; $r=.94$; $p<.01$).
- **Fires started by children**: Non-deliberate child fires accounted for 15.5 percent of all MFB fires but only 1.6 percent of CFA fires. The MFB recorded greater numbers of fires lit by 13 to 16 years olds, whereas the CFA recorded the reverse; 0 to 5 year olds accounted for a very small proportion of all vegetation fires lit by children. Both agencies reported a high number during 2001–02. For the MFB, non-deliberate child fires are significantly correlated with the total number of vegetation fires each year ($r=.89$; $p<.01$); this relationship is less rigorous for the CFA data. Seventy percent of fires attributed to children were recorded as deliberately lit; 13 percent were smoking-related
- **Inadequate control of an open fire**, vehicle fires, leaving fires unattended and abandoned, and discarded material comprised almost two-thirds of all accidental fires the CFA attended.
- The number of **escapes from campfires** the DSE attended increased slightly over the observation period (this may reflect increased usage), while the number of escapes from burn offs and smoking-related fires decreased.
- Apart from malicious activity most deliberate fires the CFA attended were associated with on-road vehicle/transportation, activity not classified, no activity, with a small number associated with commercial land-based activity, and outside activities (unclassified). Comparison of the activity variable and ignition factor variable highlight fundamental difficulties and inaccuracies in attempts to identify the extent of deliberate fire setting.
- Human-caused fires the DSE attended were relatively evenly spread between recreational users (10%), residents (8%), other (8%), farmer/grazer (7%) and children (7%); the highest percentage of deliberate causes was recorded for children, travellers, other agents and unknown agents.

Table 6: Fire cause

Agency	% Incendiary	% Suspicious	% Deliberate (known)	% Natural	% Child fires	% Smoking-related fires	% Rural burns
MFB	1.5	21.4	31	1.8	15.5[a]	30.6	unknown
CFA	0.5	32.4	41	9.5	1.6[a]	2.1	unknown
DSE	31.8		35	24.4	6.5	2.1	

a: refers to non-deliberate child fires only

Location: CFA and MFB data combined indicate that approximately 40 percent of all vegetation fires attended occurred in the Melbourne region. Regional areas that experienced the greatest numbers of fires included the Gippsland, Bendigo–Loddon, Peninsula, Melbourne East, Goulburn and Western regions. Within the Melbourne region, the greatest density occurred in the Western Melbourne, Hume City, Northern Outer Melbourne and Northern Middle Melbourne SSDs. The number of fires the DSE attended was comparatively uniform across regions; the lower numbers in the Port Phillip region reflected the DSE's less extensive tenure in that region.

Individual postcodes in Victoria recorded between one and 1,000 fires per 10,000 people per year. On average, the total numbers of fires per person decreased with increasing population size (possibly a sampling issue), but were comparatively stable for populations in excess of 1,000 people. Inner and most southern and eastern Melbourne, areas that recorded low numbers of fires overall, were typically characterised by one to 10 fires per 10,000 people per year; areas in the outer north and west of the metropolitan area had rates comparable to regional postcodes.

Collation of causal data across region was hampered by:

- differing regional structures
- differing years available for analysis
- marked variations in causes of fires across jurisdictional boundaries. The CFA recorded appreciably higher rates of deliberate fires than did the MFB, and higher rates of non-deliberate fires, the MFB documented, reflected higher contributions from smoking-related and non-deliberate child fires.

Deliberate fires, in summary:

- the greatest number and proportion of deliberate fires tended to be observed in those areas that documented the greatest numbers of vegetation fires generally, with higher numbers and proportions of deliberate fires commonly associated with outer metropolitan areas and major regional centres (that is highly populated regions)
- regions with the highest proportions of deliberate fires included Melbourne, Peninsula, Geelong and Ballarat
- within the Melbourne region, the highest number and proportion of deliberate fires occurred in the Western Melbourne, Hume City, Northern Outer Melbourne and Northern Middle Melbourne SSDs
- deliberate fires are heterogeneously distributed within individual regions; high numbers of deliberate fires were observed in several postcodes within the Melbourne, Bendigo–Loddon, Geelong, Peninsula, Goulburn, Ballarat and to a lesser extent Gippsland and Murray East regions; these postcodes typically accounted for a high proportion of fires in the region; in regional Victoria, these postcodes were associated with major regional centres
- for the DSE, the greatest numbers of deliberate fires occurred in the South West and North West regions, although high proportions of deliberate fires also occurred in the Port Phillip region; children were an important contributor to deliberate fires in both the North West and Port Phillip regions

- individual postcodes recorded between 0.1 and 100 deliberate fires per 10,000 people per year; maximum rates remained uniform across postcodes with highly contrasting population sizes; areas in outer north and west of Melbourne recorded higher rates of deliberate fires per person than areas in the centre, east and south of the city, but these figures were comparable with those typically observed in regional Victoria.

Natural fires comprised the highest proportion of fires the CFA attended in the Grampians, Murray East, Lakes, Wimmera and High Country regions; regions that overall observed the lower number of fires. The DSE attended high numbers of natural fires in the Gippsland, North East and to a lesser extent South West regions.

Recreationists contributed to the greatest proportion of fires in the North East and North West of the state.

Fires started by children: Significant correlation existed between the number of non-deliberate child fires and total number of fires in individual regions of Victoria (CFA, r=.92); a less rigorous correlation was observed for individual SSDs within the Melbourne region (MFB, r=.81), but a high correlation existed within the Melbourne region for individual postcodes (MFB, r=.91). The highest number of non-deliberate child fires occurred in the Melbourne region (particularly the Hume City, Western Melbourne, Northern Outer Melbourne and Northern Middle Melbourne SSDs). This cause was also responsible for a high proportion of fires in the Moreland City SSD.

Smoking-related fires: Within the Melbourne region (MFB data only), there was significant correlation between the number of smoking-related vegetation fires and the total number of vegetation fires within each SSD, although some dispersion in the data was evident at moderately high frequencies. The greatest number of smoking-related fires occurred in the Western Melbourne, Northern Melbourne and Eastern Middle Melbourne SSDs, but smoking-related fires accounted for the highest percentage of all fires in the Inner Melbourne (53%), Boroondara City (43%), and the Southern, Eastern Middle and Northern Middle Melbourne (37 to 40%) SSDs; that is, in more centrally located metropolitan areas where the total number of vegetation fires is low. Individual postcodes in the Melbourne region recorded between 0.2 and 25 smoking-related vegetation fires per year.

Type of complex: Most vegetation fires the CFA and MFB attended occurred on open land and fields (35% MFB; 57% CFA), roads/parking complexes (31% MFB; 30% CFA); 12 percent of MFB fires also occurred on railway property; seven CFA-attended fires occurred in scrub, bush and woods. The MFB data indicated comparatively uniform rates of deliberate fires (25 to 30%) across most areas that experienced more than 10 vegetation fires in five years, although somewhat lower rates occurred for roads/parking lots and on railway property, owing to higher contributions from accidental causes. Although most vegetation fires the CFA attended occurred in the above location, a high proportion of fires were deliberately lit along railways, at vacant structural sites, and along means of egress. MFB records indicated that the diversity of locations where non-deliberate child fires occurred increased with the age of the child, and the proportion of fires lit at single dwellings decreased.

Timing: Important aspects of the timing of vegetation fires in Victoria are summarised in terms of the time of the year, day of the week and the time of day at which they occurred.

Week of the year: Important points about distribution of fires throughout the year are summarised as:

- The principal timing of fires varied subtly between agencies; MFB, mid November and late March; CFA, mid November to mid May; DSE, mid September and late April, but the temporal distribution of fires varied markedly between years.
- Peak numbers of deliberate fires typically occurred between mid December and the end of January, being coincident with both school holidays and the peak in natural fires.

- For the MFB, there were strong parallels between the timing of non-deliberate and deliberate fires.
- For the CFA, fires associated with malicious activity and on-road vehicles/transport had very similar temporal distributions.
- The greater length of the bushfire season and difference between non-deliberate and deliberate fires for the CFA and DSE principal reflected the significant contributions from fuel reduction burning/ rubbish clearing, which peaked just before and just after the bushfire danger season.

Day of the week: More vegetation fires in Victoria occurred on weekends than on weekdays, but the extent of this increase was cause-specific.

The MFB recorded 29 to 34 percent more deliberate vegetation fires on weekend days than on the average weekday, compared with 10 percent more accidental fires. For the CFA, 30 to 40 percent more deliberate fires occurred on weekends. However, the MFB and CFA also observed that 20 to 40 percent more accidental fires occurred on weekends, relative to the average weekday. This was observed for fuel reduction burning and clearing of land, heaps and windrows, but fires relating to camping, picnicking and barbecues were more than twice as likely on weekends. The MFB recorded that between 75 and 100 more non-deliberate child fires occurred on Saturday and Sunday, whereas for the CFA 22 percent more fires occurred on Saturday but only 10 percent more fires occurred on Sunday.

Time of day: Both the MFB and CFA observed substantial differences between the timing of deliberate and non-deliberate fires, although some differences also existed in metropolitan and regional areas. These finding are summarised below:

The peak in non-deliberate fires preceded the peak in deliberate fires. The CFA observed the greatest number of accidental fires from 2 to 3 pm; with the greatest number of natural fires occurring between 2 and 4 pm. The MFB attended peak numbers of non-deliberate fires from 4 to 5 pm. The latter is somewhat later than in other jurisdictions and for the CFA and may reflect the comparatively high proportion of non-deliberate child fires.

The peak in deliberate fires was later than for non-deliberate fires. The CFA and MFB observed peak numbers of deliberate fires at 4 to 6 pm and 5 to 6 pm, respectively. The number of deliberate fires the MFB attended remained elevated until midnight; and for the CFA, the number of deliberate fires decreased by 6 pm but remained high until midnight. CFA data clearly indicated later times were evident for weekdays than for weekends.

A high proportion of deliberate fires in Victoria occurred after normal working hours; the MFB and CFA attended 60 and 45 percent, respectively, of deliberate fires that occurred between 6 pm and 6 am. In comparison, only 41 percent of non-deliberate MFB-attended fires and 23 percent of CFA-attended accidental fires occurred within this timeframe. For the MFB, high numbers of deliberate fires at night occurred on all nights of the week but increased frequencies, between midnight and 4 am, were most evident on Saturday and Sunday. For the CFA, the proportion of night fires varied between regions, being high in some remote regional areas (such as the Wimmera, Central Murray, and Mallee regions) but also in densely populated areas like Geelong.

Children: Overall, peak numbers of fires were observed around 4 to 6 pm (principally a weekday phenomena); patterns for 13 to 16 year olds most closely approximated the trends observed for deliberate fires; and 6 to 12 year olds tended to light a smaller proportion of fires at night. For the MFB, 65 percent of fires lit by 13 to 16 year olds occurred between 6 pm and 6 am; 11 percent of fires were lit between midnight and 6 am.

Area burned: Most vegetation fires, irrespective of the fire service that attended or the cause of the fire, were small. Nevertheless, differences were noted; natural fires comprised higher proportions of larger fires the DSE and CFA attended. For these agencies, deliberate fires typically accounted for a decreasing proportion of fires as fire sized increased. This was not evident of the MFB data, where fire size was overall smaller; deliberate fires accounted for a high proportion of the largest fires.

The total area burned was governed by the largest fire events. For both the CFA and DSE the data were dominated by the large natural fires that occurred in 2002–03 (approximately 70 percent for CFA-attended fires and 80 percent for DSE-attended fires), whereas, for the MFB the largest area was burned in 2000–01.

Overall:

- 5,800 ha was burned in fires the MFB attended from 1997–98 to 2001–02; 45 percent was burned by deliberate fires; six percent was burned by smoking-related fires
- 1,206,627 ha was burned in fires the CFA attended from 1999–2000 to 2003–04; only 1.4 percent was by deliberate fires
- 1.7 million ha in total was burned from 1993–94 to 2003–04; of that area, 0.5 percent was burned by deliberate fires.

Fire danger rating: Most deliberate fires the MFB attended occurred under moderate fire danger conditions, with the number of deliberate fires attended decreasing as fire danger increased. In addition:

- deliberate fires and fires started by an open flame accounted for a decreasing proportion of fires as the fire danger increased
- smoking-related fires account for an increasing proportion of fires as fire danger increased
- the greatest numbers of deliberate fires that occurred under very high to extreme conditions were located in those areas that experienced the greater numbers of fires.

Most fires the CFA attended occurred when fire restrictions, but not total fire bans, were in place; deliberate fires comprised a lower proportion of fires when a total fire ban was in place, than when no total fire ban was in place.

Fires and climate: The DSE was the agency most strongly affected by natural fire events as it documented the greatest proportion of natural fire events; years accompanied by El Niño events were commonly characterised by higher numbers of fires (particularly higher numbers of natural fires) and/or larger areas burned than in those years in which such climatic conditions are not present. Increased numbers of fires (particularly natural fires) were present early in the year. In the case of the DSE, greater numbers of deliberate fires are also evident in such year, although no single agent could be pinpointed. For the CFA, large areas may be burned in El Niño years, but there does not appear to have been a large increase in the total number of fires attended, or in the number or proportion of deliberate fires. Fires the MFB attended appear to show the least relationship with large-scale climatic variables.

Sources of information

ABS 2001a. *Australian standard geographical classification*. ABS cat. no. 1216.0. http://www.abs.gov.au/ausstats/abs@.nsf/cat/1216.0

ABS 2001b. *Postal area to statistical local area concordance, Australia, 2001*. ABS cat. no. 1253.0. http://www.abs.gov.au/ausstats/abs@.nsf/cat/1253.0

ABS 2005a. *Population by age and sex, Victoria*. ABS cat. no. 3235.4.55.001. http://www.abs.gov.au/ausstats/abs@.nsf/cat/3235.2.55.001

ABS 2005b. *Tourism region maps and concordance files, Australia, 2005*. ABS cat. no. 9503.0.55.001. http://www.abs.gov.au/ausstats/abs@.nsf/cat/9503.0.55.001

ABS 2006. *Australian demographic statistics*. ABS cat. no. 3101.0. http://www.abs.gov.au/ausstats/abs@.nsf/cat/3101.0

APC 2006. *Report on government services 2006, Part D: emergency management*. http://www.pc.gov.au/gsp/reports/rogs/2006/emergencymanagement/index.html

Australia. Department of Environment and Heritage 2001a. *Land use: Victoria*. Accessed through http://audit.deh.gov.au/ANRA/atlas_home.cfm

Australia. Department of Environment and Heritage 2001b. *Native vegetation types and extent: Victoria*. Accessed through http://audit.deh.gov.au/ANRA/atlas_home.cfm

Australian Bureau of Meteorology 2007. *Average rainfall, annual: Victoria*. Accessed through. http://www.bom.gov.au/climate/map/temperature/IDCJCM0005_temperature.shtml

CFA 2007. *CFA/MFESB areas*. www.cfa.vic.gov.au/about/mfesb.htm

Davies C 1997. *Analysis of fire causes on or threatening public land in Victoria 1976/77–1995/96*. Victoria: Department of Natural Resources and Environment. http://www.dse.vic.gov.au/DSE/nrenfoe.nsf/FID/-4AFB74B010B7E9844A256862001C6C1D?OpenDocument

DSE 2007a. *DSE fire regions: fireplan*. http://nremap-sc.nre.vic.gov.au/MapShare.v2/imf.jsp?site=fireplan

DSE 2007b. *Fire and other emergencies: Ash Wednesday 1983*. http://www.dse.vic.gov.au/dse/nrenfoe.nsf/childdocs/–D79E4FB0C437E1B6CA256DA60008B9EF–7157D5E68CDC2002CA256DAB0027ECA3?open

DSE 2007c. *Fire and other emergencies: Black Friday 1939*. http://www.dse.vic.gov.au/dse/nrenfoe.nsf/childdocs/–D79E4FB0C437E1B6CA256DA60008B9EF–8AC9C23269FA53B4CA256DAB0027ECC4?open

Ellis S, Kanowski P & Whelan R 2004. *National Inquiry into Bushfire Mitigation and Management*. Canberra: Commonwealth of Australia. http://www.coagbushfireenquiry.gov.au/findings.htm

EMA 2006a. *EMA disasters database: 1851*. http://www.ema.gov.au/ema/emadisasters.nsf/c85916e930b93d50ca256d050020cb1f/cf9689ce3ecab569ca256d3300057cc3?OpenDocument

EMA 2006b. *EMA disasters database: 1939*. http://www.ema.gov.au/ema/emadisasters.nsf/c85916e930b93d50ca256d050020cb1f/f3b24a29f0055fb2ca256d3300057c33?OpenDocument

EMA 2006c. *EMA disasters database: 1943*. http://www.ema.gov.au/ema/emadisasters.nsf/c85916e930b93d50ca256d050020cb1f/0b786be0a48e7fe5ca256d3300057c3b?OpenDocument

EMA 2006d. *EMA disasters database: 1969*. http://www.ema.gov.au/ema/emadisasters.nsf/c85916e930b93d50ca256d050020cb1f/7cdf4e81d1bd065aca256d3300057ba3?OpenDocument

EMA 2006e. *EMA disasters database: 1983*. http://www.ema.gov.au/ema/emadisasters.nsf/c85916e930b93d50ca256d050020cb1f/76b9d4d54b20e8ffca256d3300057bd4?OpenDocument

MFB 2007. *Annual reports*. http://www.mfb.vic.gov.au/default.asp?casid=561

Rimmington, GM & Nicholls, N 1993. Forecasting wheat yields in Australia with the Southern Oscillation Index. *Australian journal of agricultural research* 44(4): 625–632

Queensland

Contents

The first part of this chapter provides **contextual information** on Queensland, including basic information about its climate, geography, land use and population. It also provides an outline of the bushfire regimes, historically important bushfire events, and overview of fire services in Queensland. The second part represents an **analysis of data** provided by the Queensland Fires and Rescue Service, Forestry Plantations Queensland and Queensland Parks and Wildlife. Although some agencies may attend many types of fire incidents, and that data may have been supplied, this analysis exclusively refers to vegetation fires only, unless otherwise indicated.

For an explanation of the key terms, limitations and methodology refer to the introduction, glossary and methodology chapters.

Introduction

Covering an area of 1,722,000 square kilometres, Queensland is the second largest state in Australia, after Western Australia. It is located in the northeast of mainland Australia, and is bordered by the Northern Territory and South Australia in the west and New South Wales in the south. To the north lie the Coral Sea and the Pacific Ocean.

Geography

Queensland is geographically diverse. More than 2,000 km of its 7,400 km of coastline is laced with coral reefs (Figure 1). The Great Dividing Range extends from the state's southern border with New South Wales to almost its northern tip on Cape York Peninsula. The range reaches a maximum of 1,622 m at Mount Bartle Frere southwest of Cairns and forms an important climatic and geographical barrier.

Rainfall in southern Queensland, inland of the range, feeds into the extensive Murray–Darling River system, which drains through New South Wales and Victoria, before reaching the sea in South Australia. The Outback region of Queensland is characterised by vast open and largely inhospitable plains; closer to the range, where soils are more fertile and rainfall more predictable, there are vast areas of agriculture, mainly livestock and cereal production.

The northwest contains rugged uplands rich in mineral deposits. From there the land falls gently to the coastal plain. Broad tracts of salt flats mark the area around the Gulf of Carpentaria; and a narrow coastal plain runs along the entire eastern seaboard. Brisbane, the capital, is located in the southeastern corner of the state.

Figure 1: Map of Queensland

Climate

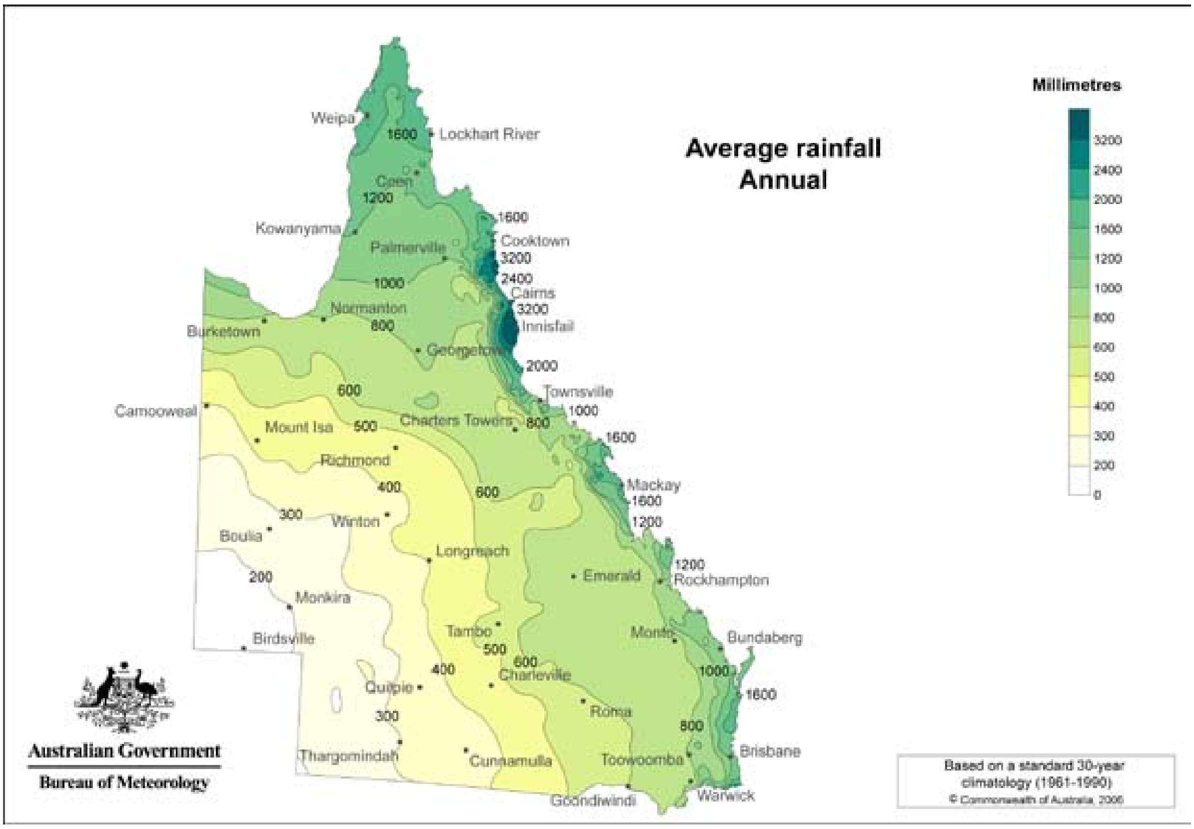
Queensland's climate is warm year round, with two main seasons; a dry winter, during which temperatures are commonly slightly lower than the rest of the year, and a hot humid summer. The lowest average maximum temperatures in summer occur along the east coast and ranges (January, 24 to 30°C). The minimum night-time temperatures in coastal areas decrease southwards, but no systematic differences occur in average daily maximum temperatures. Average daily summer temperatures increase inland, with more than one-third of Queensland recording average daily maximum temperature in January greater than 36°C. Average minimum night-time temperatures during January in inland Queensland are typically 21 to 27°C (Australian Bureau of Meteorology 2007a).

Average winter minimum temperatures increase northwards and decrease inland. Average daily maximum and minimum temperatures in Brisbane (southeast coast) in July are 18 to 21°C and 9 to 12°C, respectively. In contrast, minimum daily temperatures in northern Queensland in June typically exceed 15°C, and maximum daily temperatures commonly exceed 27°C (Australian Bureau of Meteorology 2007a).

Rainfall is highly variable across the state, ranging from greater than 3,200 mm on the northeast coast to less than 200 mm in the southwest of the state (Figure 2). Annual rainfall on the coast and ranges typically exceeds 800 mm, whereas areas just west of the ranges typically records 500 to 800 mm per annum (Australian Bureau of Meteorology 2007b).

Much of northern Queensland in dominated by monsoonal rainfall; that is, rainfall is concentrated within a distinct wet season, with little rain falling during the dry season. However, restricted areas of the northeastern coast experience copious rainfall all year round. Southern Queensland also tends to experience maximum rainfalls in summer, but there is little distinction between seasons. For example, there is sufficient winter rainfall to support the winter cropping of wheat. Rainfall extremes are not uncommon, with many regions being subject to both extremes of drought and flood because rainfall is commonly linked with the movement of low-pressure systems and tropical cyclones across the northern part of the state. Risk of damage from tropical cyclones is high in the northern part of the state.

Figure 2: Average annual rainfall for Queensland

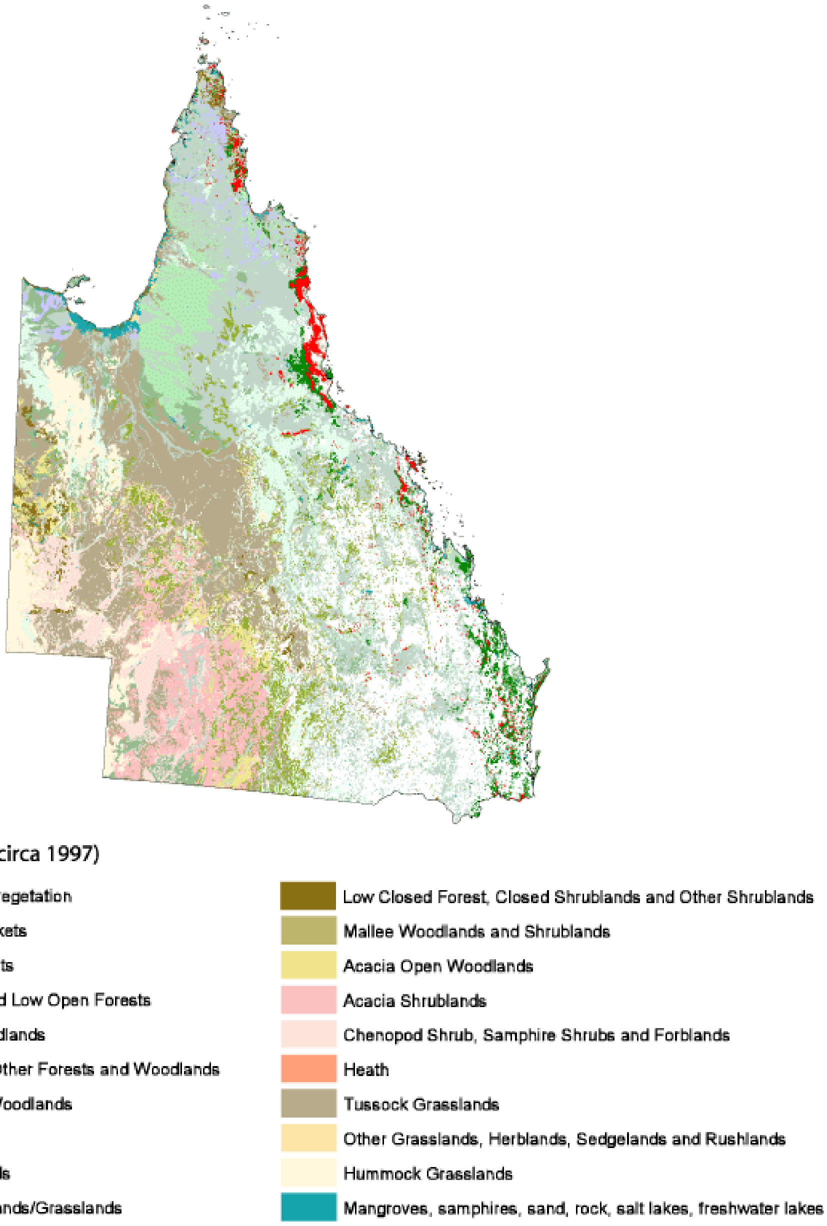


Source: Australian Bureau of Meteorology 2007b

Native vegetation

Vegetation in Queensland is highly diverse, reflecting the great variety of climatic conditions experienced across the state. Coastal areas are mainly covered by eucalyptus open forest and woodland, with pockets of tropical and subtropical rainforests scattered in coastal and near-coastal valleys and ranges (Figure 3). Farther inland, acacia low woodlands of brigalow, mulga, and gidgee dominate, with grasslands occurring on heavier soils. The arid interior is sparsely vegetated with large areas being dominated by tough, spiky, tussocky spinifex grass, chenopod shrub (saltbush and bluebush), samphire shrublands (low shrubland of salt tolerant species) and other grasslands. Much of northern Queensland falls within the broad swathe of tropical and, to a lesser extent, equatorial savannas that extends across northern Australia (Australia. Department of Environment and Heritage 2001b).

Figure 3: Native vegetation groups (c. 1997)



Source: Australia. Department of Environment and Heritage 2001b

Land use

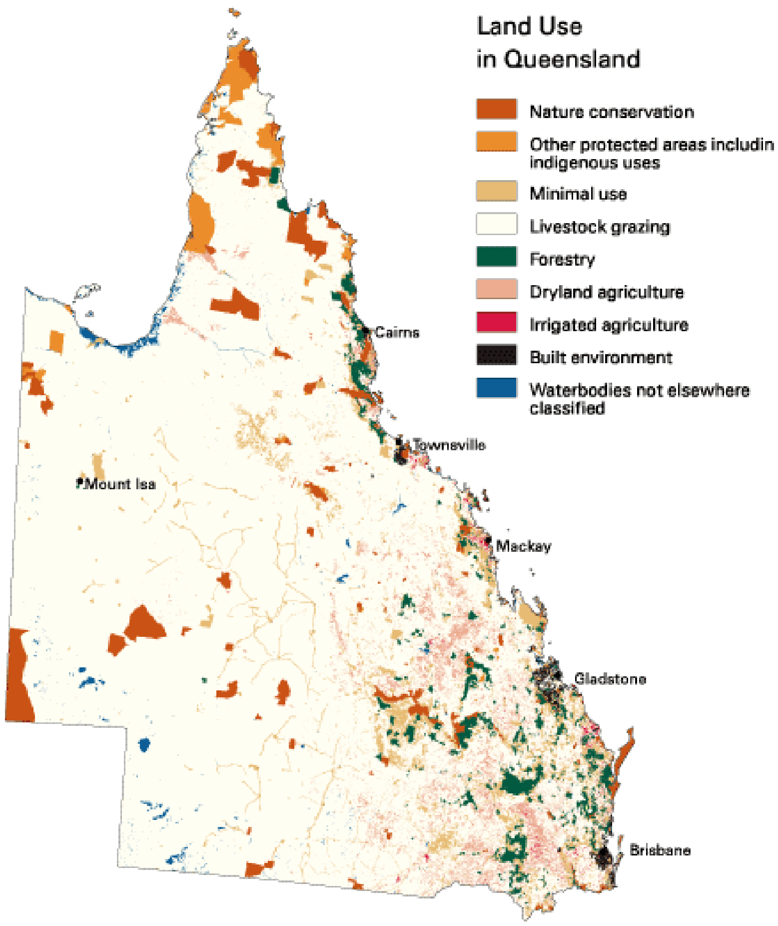
Collectively, 96 percent of Queensland is used for agriculture. As of 1996–97 almost 82 percent of Queensland was used for livestock grazing, with Queensland being the leading beef-producing state of Australia. The state is also Australia's main producer of sugar cane (coastal regions), and a wide variety of cereal crops, citrus, tropical and exotic fruits and vegetables. Dryland agriculture principally occurs on the mountain ranges and coastal plain in the southern half of the state (Figure 4).

In 1996–97, three percent of the state was devoted to forestry, with another four percent being reserved for nature conservation. Since then complex changes in land management have resulted in substantial, but ongoing transfers between various land management agencies, making it difficult to specifically state the areas under conservation and forestry at any given time. Although the 1996–97 figures do no accurately reflect the current status of tenure or land use, collectively the area devoted to forestry and conservation combined are not markedly changed since then.

In addition, there are several large protected areas, including Indigenous use areas, many of which lie on the Cape York Peninsula. As well, 9.7 million hectares of land are of minimal use, three-quarters of which consists of remnant native vegetation cover on private land.

Other major industries in Queensland include mining (coal, copper, lead, bauxite and zinc) and tourism (Australia. Department of Environment and Heritage 2001a).

Figure 4: Land use (c. 1996–97)



Source: Australia. Department of Environment and Heritage 2001a

Population

The resident population of Queensland as at 30 June 2006 was 4,053,400, with Queensland accounting for 19.7 percent of Australia's population (ABS 2006a). The majority of the population lives in urban areas in the southeast corner, with approximately two-thirds living in the statistical divisions of Brisbane and Moreton. The population in southeast Queensland is among the fastest growing of any region in Australia. Other major regional centres outside the southeast of the state include Cairns, Townsville, Mackay, Rockhampton, Bundaberg, Toowoomba, and Mount Isa (ABS 2005a).

As at 30 June 2005, the median age of Queensland's population was 35.9 years, marginally lower than the national value of 36.6 years. However, the age distributions of the population were variable at local scales. Excluding statistical local areas with less than 2,000 people, 13 statistical local areas had a median age over 45 years. Of these, eight were in the Moreton statistical division in southeastern Queensland, three were in the Brisbane statistical division, and one each were recorded in the Wide Bay–Burnett and Fitzroy statistical divisions. Fifteen statistical local areas had a median age of less than 30 years, of which six were in the Brisbane statistical division (generally close to higher educational institutions). Another six were in the Northern statistical division, principally around Townsville (ABS 2005a).

As at 30 June 2005, 20.4 percent of the state's population was aged 0 to 14 years. The highest proportions of people within the age group occurred in the North West (26.0%) and South West (23.6%) statistical divisions; the lowest were in the Moreton (18.9%) and Brisbane (20.0%) statistical divisions (ABS 2005a).

Bushfire regimes

Subtle variations in the timing of the bushfire season occur across Queensland (Figure 5). In southeastern and central Queensland, bushfires typically occur during dry spring conditions. In the tropical savannas, bushfires typically occur during the dry season (winter and spring), although the exact timing may vary with latitude and distance from the coast.

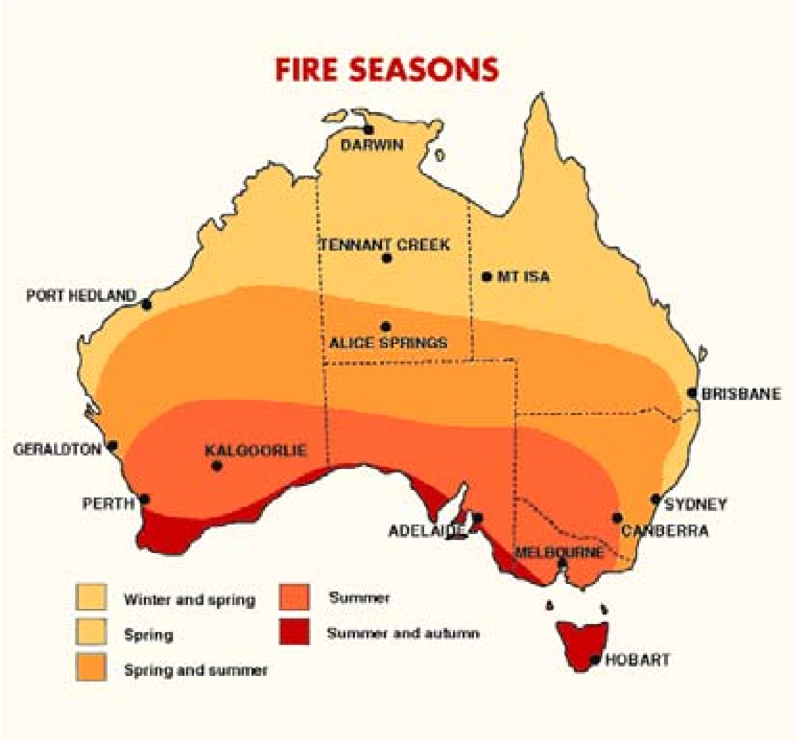
Fire regimes also vary enormously across the state in terms of both size and frequency. The tropical savannas of northern Queensland are characterised by frequent large burns, with human beings playing a central role in determining the fire regions. Commonly one-third of the savannas are burned every year. Although intense, hot fires are not unknown, many savanna fires are of low intensity, and will less commonly result in loss of property or injury.

In contrast, subtropical and tropical rainforests along the east coast are extremely sensitive to fire, and a bushfire in these regions may have disastrous consequences for biodiversity. Between these extremes lie the acacia scrublands and woodlands of southern central Queensland and eucalypt open forests on the coastal plains and ranges, which do experience bushfires, but less frequently than the savannas.

Given differences in size, intensity, frequency, potential damage, environmental impacts and cause of fires, some caution is needed in attempting to integrate bushfire data from these various regions. For example, a 10,000 ha fire in Cape York's tropical savannas would be essentially negligible in terms of the total area burned in a year and is unlikely to pose a high risk to the inherently sparse population. Indeed, there may be no attempt to suppress the fire as it would either pose no problem or may be considered beneficial to maintaining the area's biodiversity. By contrast, an equivalent fire in eucalypt forests in the southeast may result in loss of life and property and great efforts are therefore likely to be devoted to its suppression.

The nature and burning practices that occur in the tropical savannas are unique. Readers unfamiliar with this topic are encouraged to read the introduction for the Northern Territory, before proceeding with the Queensland analysis.

Figure 5: Timing of bushfire seasons in Australia



Source: Australian Bureau of Meteorology 2007c

Bushfire history

Although Queensland is typically a state that sustains greater losses from cyclones and floods than from bushfires, it has experienced several devastating bushfires that have resulted in loss of life and property; as well as very large areas that were burned without extensive loss of life or property (Table 1). The 2002–03 season is discussed in detail below.

2002–03: Collectively, 2,780 bushfires occurred in Queensland during 2002–03, burning 8 million ha of land. Between 16 and 29 October 2002, three major fires broke out the Stanthorpe district (Ballandean), the Toowoomba Range and Tara (west of Dalby). The Ballandean fire, which resulted from the arcing of overhead power lines, burned 18,500 ha, was responsible for the death of one person, destroyed four houses and caused $6.5 million in damages. The Toowoomba Range fire started at a railway siding near Mount Kynoch. The two resulting fire fronts burned 18,000 ha in rugged country, on the urban fringe, and in low-density urban areas. Approximately 1,000 people were evacuated; 10 structures were destroyed and a further 20 were damaged. The Tara fire resulted when an existing fire broke containment lines and moved rapidly toward residential areas; another fire in the area was though to be deliberately lit. Collectively, the Tara fires burned 3,350 ha. Several hundred people were evacuated, and six homes were destroyed (Ellis, Kanowski & Whelan 2004).

Table 1: Fire history of Queensland

Date	No. of deaths	Area of fire (ha)	Losses	Location(s)
1917	3			Large fires near Hughenden, followed by a fire on Warenda Station
1918 October	2		>100,000 sheep	Fires spread over a huge area from Charleville to Blackall, Barcaldine, Hughenden
1918 October	5			Saltern Creek
1926			Forests, farms, sugar cane, banana plantations and dwellings	Southeast corner of Queensland
1940		80,000		Goomeri
1941 July, August		120,000		Julia Creek and Barkly Tableland, Richmond and Cunnamulla
1941 September				Tangorin, Winton, St George, Dalby, Julia Creek, Muttaburra, Longreach
1943		45,000		Dirranbandi
1950 December		49,000	Mostly pasture	Wyandra, Charleville, Adavale, Langlo, Quilpie, Augathella, Cunnamulla, Thargomindah
1951 January, February		2,834,000	40,000 sheep, 550 stock, 650 km fencing	Charleville
1951–52 season			£2 million (1952 values) in stock and fencing	This was regarded as a bad fire season throughout the state
1954 November	3			Narollah Station, Hughenden area
1964–65 season		92,000	Cypress pine, grazing land, hardwood forest	Roundstone, Dunmore, Fraser Island, Toolara, Tin Can Bay, Badderam Holding
1965 November		97,940		Nara Holding (Croydon district)
1972–73 season		2,000	100 cattle	Arcadia Valley
1974 October to 1975 February		7,300,000	95 cattle, 6,850 sheep	Thargomindah, Bulloo Shire, Boulia Urandangie, McKinlay Shire
1976 May to December		1,891,600	5 km fencing, 5,968 sheep, 32 properties, cypress pine forests	Julia Creek, Coalbrook Station, Hughenden, South Burnett, Nanango and Brisbane Valley, Inglewood–Millmerran
1979		421,400	41,000 sheep, 400 cattle	Julia Creek, McKinlay Shire
1990–91 season	3			Two children killed in a fire in Tambo; Bald Knob, Landsborough, Mapleton, Palmwoods (Sunshine Coast hinterland)
1991–92 season	1		3 houses	Mount Tamborine (Gold Coast hinterland)
1992–93 season		40,000	4 houses, several vehicles	Coominya rural residential area near Esk
1994 September, November		5000	Plantation timber ($35 million)	Beerburrum State Forest
1995 September, November		333,000	9 volunteers severely injured, 23 houses, 93 buildings, fences, livestock	Southeast Queensland
1996 October			1 house (Ravensbourne)	Southeast Queensland
2000 August			1 volunteer severely burned, 3 buildings, 3 vehicles	Hundreds of bushfires in southeast (majority deliberately lit)
2001		1,600,000	National park, grazing land	Lawn Hill
2002 October	1	40,000	10 houses, 11 buildings, 30 structures destroyed or damaged	Stanthorpe District, Toowoomba Range, Tara

Source: Ellis, Kanowski & Whelan 2004

Fire services

Three major agencies provide fire services in Queensland. They are the Queensland Fire and Rescue Service, Forestry Plantations Queensland and the Queensland Parks and Wildlife Service.

The **Queensland Fire and Rescue Service** (QFRS) incorporates two distinct arms that operate in largely urban and rural areas respectively. The QFRS employs full-time and part-time (auxiliary) firefighters to staff more than 240 urban fire and rescue stations across Queensland. This arm of the QFRS responds to fires in homes, buildings, vehicles and on the land, but also performs rescues, chemical and hazardous material management, among other tasks. It provides fire and rescue services to the majority of Queensland's population. The Queensland Rural Fire Service (QRFS) is a distinct body within the QFRS that provides fire services in the remaining 93 percent of the state. As the name implies, the QRFS's jurisdiction is principally within regional, rural and remote areas, where the population density is comparatively low. There are about 1,550 rural fire brigades, with approximately 41,000 volunteers, and a warden network of 2,445. Although its jurisdiction lies outside that covered by land management agencies, the QFRS (including the QRFS) will attend fires in those areas and vice versa. For more information about the QFRS see http://www.fire.qld.gov.au.

Forestry Plantations Queensland (FPQ) is responsible for hazard-reduction and fire-response capability for the forests under its management. As at 30 June 1988, Queensland had approximately 4.5 million hectares of state forest and timber reserves. This included about 165,000 ha of plantations of which 99 percent were softwoods; the remainder was native forest. Of this, 20 percent was rainforest and not a fire hazard. The name, structure and jurisdiction of the FPQ have changed many times in the last 30 years. In 1989 Forestry became a commercial business unit within the Department of Primary Industries. Two name changes followed: in 2006, forestry (principally forestry plantations) came under the control of Forestry Plantations Queensland, a state government owned corporation. In addition to the name changes, several tenure transfers and realignments have affected the lands that fell within these various organisational jurisdictions, namely:

- in 1989, 899,000 ha of 'wet tropics' was World Heritage listed; of this, 80 percent was rainforest, but the remainder was subject to fire
- around 1992, 163,000 ha on Fraser Island was also World Heritage listed; the majority of this is eucalypt forest
- under the South East Queensland Regional Forests Agreement (December 1999), much of the native forest in State Forests became Forest Reserve (conservation status), passing directly into Environmental Protection Agency (Queensland Parks and Wildlife Service) control. Most of the remainder was/is proposed for one logging after which it reverts to National Parks and Wildlife, as State Forest Reserve. The native forests that have been set aside for logging are now managed by Natural Resources and Water (Forest Products).

Small areas of native forests are included within the boundaries of State Forest Plantations, managed by FPQ. These native forests commonly occur along watercourses and other environment buffers, or as an external strip adjacent to the plantations, and provide fire protection buffers for plantations. For more information about Forestry Plantations Queensland see http://www.fpq.qld.gov.au/asp/index.asp.

Queensland Parks and Wildlife Service (QPWS), which falls under the umbrella of the Environmental Protection Agency, now provides fire management for an estate of nearly 12 million ha. These lands are principally protected areas such as national parks and a considerable area of state forest under joint management with commercial forest agencies. QPWS fire management includes a considerable involvement in planned burning for ecological and hazard reduction purposes and wildfire response. The most significant changes in the land tenure and management portfolios have occurred subsequent to the South East Queensland Regional Forests Agreement. Before 1975, the Department of Forestry managed about four million hectares of forestry reserves and one million hectares of national parks. As noted, these lands are now managed by three agencies, the QPWS, FPQ and the Natural Resources and Water, Forest Products Branch. The lands under QPWS jurisdiction have expanded by 11 million hectares since 1975. For more information about QPWS see http:///www.epa.qld.gov.au.

Several **other agencies** are also responsible for fire management in Queensland. The structure of responsibilities for fire management in Queensland, as at May 2000, is broadly outlined in Table 2. The South East Queensland Regional Forests Agreement has also had an impact on the role of the Queensland Department of Natural Resources, now the Department of Natural Resources and Water (DNRW).

The analysis of Queensland fires was restricted to data derived from the QFRS, FPQ and QPWS. It is recognised that the DNRW and other agencies listed in Table 2 may also hold fire statistics, but these are not included within this analysis. It is also recognised that more than one agency may attend the same fires, and hence will be duplicated across those databases. No attempt has been made to identify such duplications.

Table 2: Agencies responsible for fire management in Queensland (c. May 2000)

Agency	Fire management responsibility on public lands
Local government	Public lands for which local government is trustee (road reserves, parks and recreation reserves, water reserves, etc.)
EPA[a]	Protected areas
DNR[a]	Unallocated state land and unmanaged reserves
DoT[a]	Transport corridors
DPI (FS)[a]	State forests and timber reserves
QFS[a]	Urban areas
Landholders	Freehold land and leasehold land for which they are responsible

a: EPA – Environmental Protection Agency (includes Queensland Parks and Wildlife Service); DNR – Department of Natural Resources; DoT – Department of Transport (Q-Rail and Roads); DPI (FS) – Department of Primary Industries (Forest Service); QFS (now QFRS)

Source: Queensland Department of Natural Resources and Water 2000

Queensland Fire and Rescue Service analysis

Background about the QFRS dataset and its analysis

Important information about the QFRS dataset and the methodology employed to analyse it is summarised as:

- Data were sourced from Australasian Fire Authorities Council (AFAC).
- The database included data from 1997–98 to 2001–02. However, although the QFRS introduced the AIRS system in 1997–98, full incident reporting was not it place for several years. Moreover, this dataset only included fires reported by urban stations; the reporting of fires within the AIRS database, by volunteers in rural areas (QRFS), is voluntary.
- The data were classified using Australian Incident Reporting System (AIRS) classification codes.
- The dataset provided included fires of all causes (structural, vehicle, vegetation and other). Only vegetation fires (AIRS wildfires; Type of Incident code 160 to 179) were analysed. Hence, all references to fire refer to vegetation fires, and do not include other fire categories.
- The cause of fires was defined using the ignition factor variable.

- Deliberate fires include all fires classified as incendiary (AIRS ignition factor code 110 or 120) or suspicious (AIRS ignition factor code 210 or 220).
- Natural vegetation fires refer to all fires where the ignition factor codes were 800 to 890, which incorporate any fire resulting from a natural condition or event. For the QFRS, the breakdown of specific causes of natural fires was: high wind 52.6 percent, lightning 21.3 percent, high water (including flood) 0.4 percent, and any other natural condition (not classified [NC]/insufficient information to classify further [IO]) 25.6 percent.
- The dataset included the form of heat ignition variable.
- Smoking-related fires were classified based on: 'Form of heat of ignition' = 'Heat from smokers' materials' (AIRS codes 300 to 390). The cause of smoking-related fires was 75 percent accidental, three percent incendiary, nine percent suspicious, and nine percent unknown.
- All fires started by children were identified within the database as resulting from children playing and were therefore considered non-deliberate or accidental. No information was available about the number of malicious fires children started, as these fires were classified as incendiary or suspicious, and cannot be delineated from other fires included within these categories.
- The database included information about 'type of incident'.
- Regions used in the QFRS analysis are based on ABS (2005b) tourism regions. However, there is not an exact correspondence between tourism regions used in this analysis and ABS tourism regions. In this study, assignation was based on the highest levels of concordance between postcodes and tourism regions, but ABS tourism regions are constructed from smaller statistical areas that potentially crosscut suburban and postcodes boundaries.
- Statistical region sectors were used to examine the distribution of fires in southeast Queensland. The ABS defines statistical region sectors using a subset of neighbouring statistical local areas. While this report follows the ABS guidelines in generating statistical region sectors and uses ABS' terminology for them (ABS 2001a), fundamental differences exist between the sectors used in this report and those the ABS uses. Notably, in this analysis statistical region sectors were generated from SLA, which themselves were generated from the highest levels of concordance between postal areas and statistical local areas, using the ABS *Postal area to statistical local area concordance* (ABS 2001b). However, the ABS statistical local areas commonly crosscut postal areas and postcodes.
- The dataset supplied included information pertaining to the area burned.
- Information was available about the bushfire danger in approximately one-quarter of cases.

For more detail about these methodologies see the methodology chapter.

Note: All references to QFRS data in this report, and any conclusions drawn, relate only to data from urban-based stations and cannot be considered representative of QFRS vegetation fires overall.

Overview

Fires the QFRS attended can be summarised as:

- The QFRS (urban stations only) attended 45,525 fires from 1997–98 to 2001–02, representing an average of 9,105 (SD=2,831) per year. The total number of vegetation fires recorded in any one year varied between a low of 5,352 in 1998–99 and a high of 12,400 in 2000–01 and 2001–02 (Figure 6). The increase in the frequency of vegetation fires may not reflect genuine changes in fire frequency, as there was likely some lag between the introduction of AIRS in 1997 and full incident reporting within that system (QFRS personal communication 2005).

- Thirty percent of fires were small vegetation fires (generally less than one ha), with a further 30 percent grass fires, and 33 percent scrub, bush and grass mixed fires. Only one percent comprised forest or wood fires greater than one ha.
- Causal attributions were only made in 21 percent of cases. Of these, eight percent were incendiary, with a further 37 percent regarded as suspicious. Hence, deliberate causes comprised 45 percent of 'known' causal attributions.
- Approximately half of all fires urban fire services attended in Queensland occurred in the Brisbane region.
- A total of 2,166,640 ha were burned in fires attended from 1997–98 to 2001–02. Fires of known causes accounted for 19 percent of the total area burned. Incendiary fires accounted for 1.6 percent and suspicious fires 9.7 percent of the area burned by fires of known causes.

Cause

The proportion of fires of 'known' cause was low, only being assigned in 20.7 percent of cases (Figure 6). Hence, the documented cases of deliberate lighting (incendiary and suspicious causes combined) were also low, with deliberate causes being assigned to 9.2 percent of all vegetation fires attended.

Of those cases where causal attributions were made, 7.8 percent were identified as incendiary, and 37 percent were regarded as suspicious (Figure 7). A further 37 percent of attributed fires resulted from accidental causes and 3.9 percent from natural ignitions. Although some caution is needed in extrapolating these results to the entire dataset in light of the comparatively small proportion of cases where attributions were made, 45 percent of all 'known' attributions were classified as deliberate. This is comparable to the rates FPQ and QPWS reported as well as by agencies from other Australian states and territories.

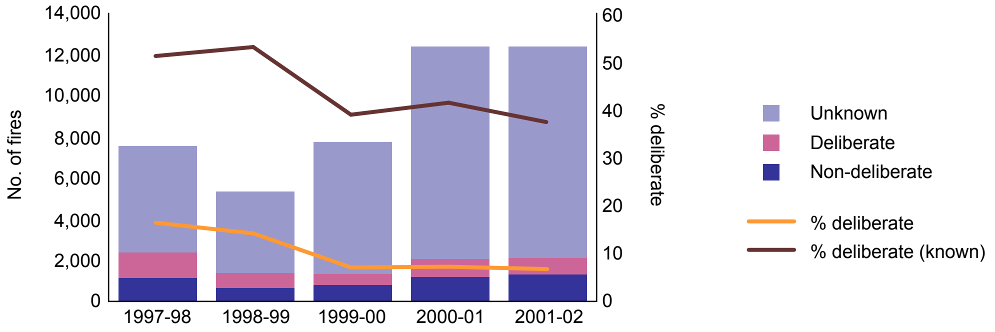
The percentage of vegetation fires that were documented as having resulted from deliberate causes dropped from 14 to 16 percent in 1997–98 and 1998–99 to 7 to 9 percent from 1999–2000 to 2001–02. Although this in part reflects the greater proportions of fires of unknown causes, the percentage of fires of 'known' cause that were classified as deliberate also decreased. Notably, deliberate causes accounted for 51 to 53 percent of known causes in 1997–98 and 1998–99 but only 37 to 44 percent from 1999–2000 to 2001–02 (Figure 6).

Specific ignition factors

Form of heat of ignition: The heat source contributing to ignition was identified for 16.8 percent of all vegetation fires (all causes). Of these, most resulted from the use of an open flame (Figure 8), principally matches (59% of the open flame category), followed by burn offs (13% of open flame category) and cigarette lighters (9% of open flame category). Fires started by cigarette lighters were likely under-represented owing to the lower probability of detection. Other important forms of heat of ignition included smoking-related materials (12% of known) and hot object or friction (8% of known).

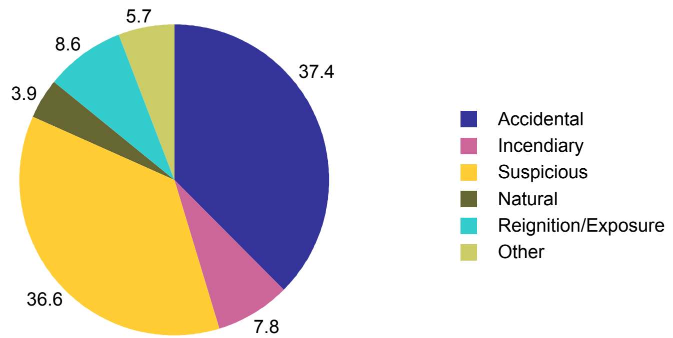
Differences exist in the proportion of known attributions and types of heat of ignition responsible for deliberate and non-deliberate fires. The form of form of heat of ignition was identified for 83 percent of non-deliberate vegetation fires, but only 45 percent of deliberate vegetation fires. Approximately 90 percent of deliberate fires, where the form of heat of ignition was identified, resulted from the use of open flame/spark (Figure 9). In contrast an open flame or spark was only responsible for 52 percent of non-deliberate fires where the form of heat of ignition was identified. This reflects the greater diversity in the types of heat of ignition responsible for non-deliberate fires. Approximately 16 percent of all non-deliberate fires were smoking-related. Smaller numbers of non-deliberate vegetation fires resulted from a hot object or friction, hostile fires, from fuel-powered machinery, and electrical equipment. There were 10 recorded cases of where an incendiary device was identified as being responsible for a deliberate ignition.

Figure 6: Cause of fires by year



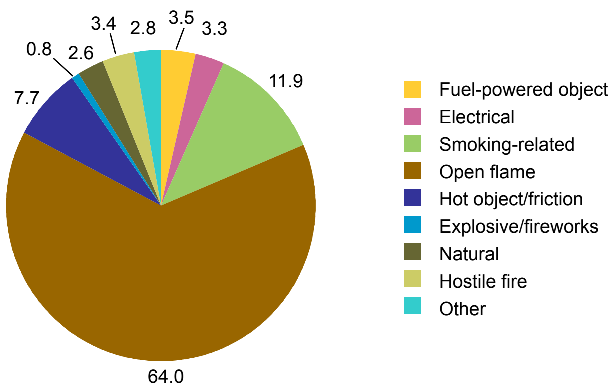
Source: QFRS 1997–98 to 2001–02 [computer file]

Figure 7: Cause of fire where 'known' (percent)



Source: QFRS 1997–98 to 2001–02 [computer file]

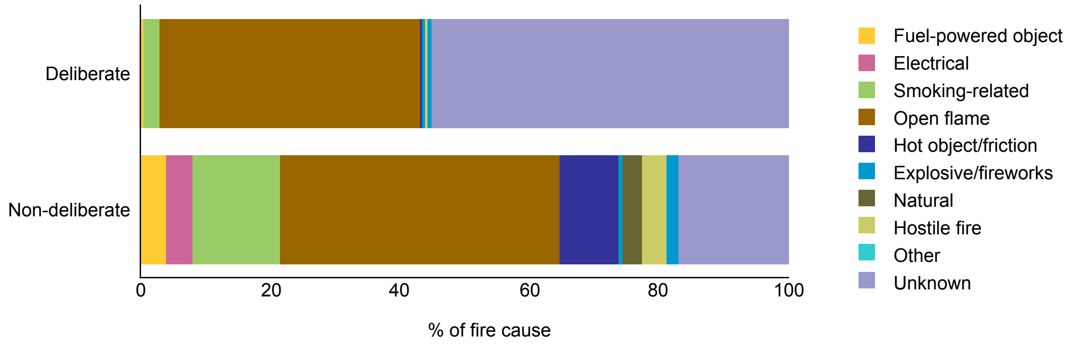
Figure 8: Form of heat of ignition where known[a] (percent)



a: form of heat of ignition known in 16.8 percent of cases

Source: QFRS 1997–98 to 2001–02 [computer file]

Figure 9: Form of heat of ignition for deliberate and non-deliberate causes



Source: QFRS 1997–98 to 2001–02 [computer file]

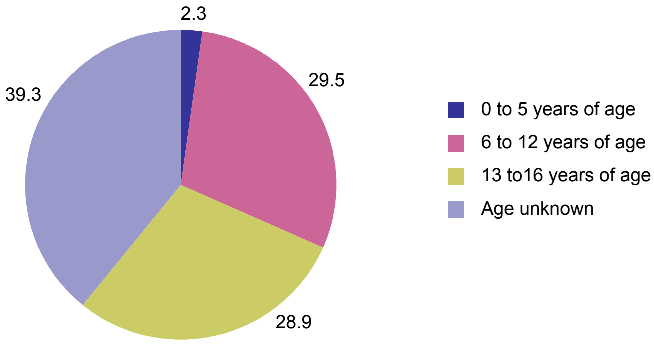
Fires started by children: In this study all fires identified as having been lit by children aged 16 years or under were non-deliberate (accidental in origin). It is impossible to ascertain the number of fires deliberately lit by children as fires lit maliciously by children are classified as incendiary or suspicious and cannot be delineated from other fires within those categories.

Children aged 16 years or younger were recorded as starting 1,089 non-deliberate vegetation fires in the reporting period. This represented 2.4 percent of all vegetation fires the QFRS documented, but 12 percent of instances where the ignition factor (cause) was assigned. Only a small fraction of non-deliberate child fires resulted from fire-play or experimentation by children 5 years of age or younger. The vast majority of non-deliberate child fires were started by 6 to 12 year olds (30%) and 13 to 16 year olds (29%) (Figure 10). The age of the children thought responsible was unknown in 39 percent of cases.

The greatest number of non-deliberate child fires occurred in 2000–01 and to a lesser extent 2001–02 (Figure 11), coinciding with greatest number of vegetation fires generally. Overall there was an excellent correlation between the numbers of non-deliberate vegetation fires lit by children and total fire numbers in any one season ($r=0.99$; $p<.001$). This means that although the actual frequencies varied, the proportion of fires children started remained comparatively constant across years. Fires attributed to children accounted for between 2.2 and 2.6 percent of all fires in any given year (Figure 11).

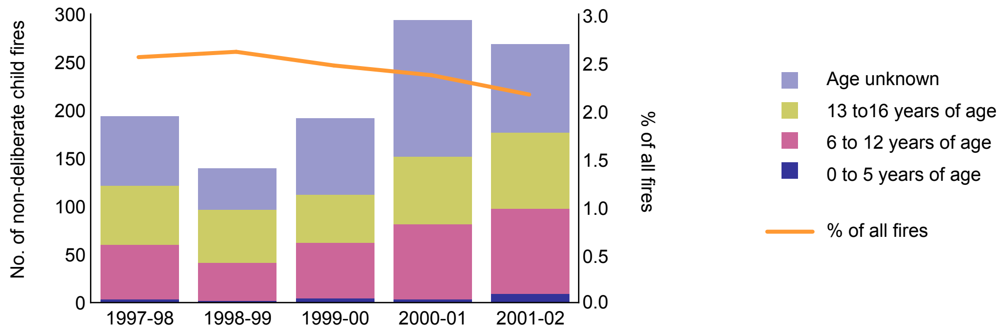
Of those non-deliberate fires attributed to children, 87 percent resulted from misuse of heat of ignition; the remainder was the result of misuse of materials ignited. The overwhelming majority resulted from the heat from an open-flame spark, irrespective of age (Figure 12). Of these, matches were the most common source of heat documented, followed by lighters, with lesser contributions from other causes (Figure 13). There was a tendency for the proportion of fires resulting from matches to increase with age. Overall, more complex forms of heat of ignition arose as the age of children increased.

Figure 10: Non-deliberate child fires by age



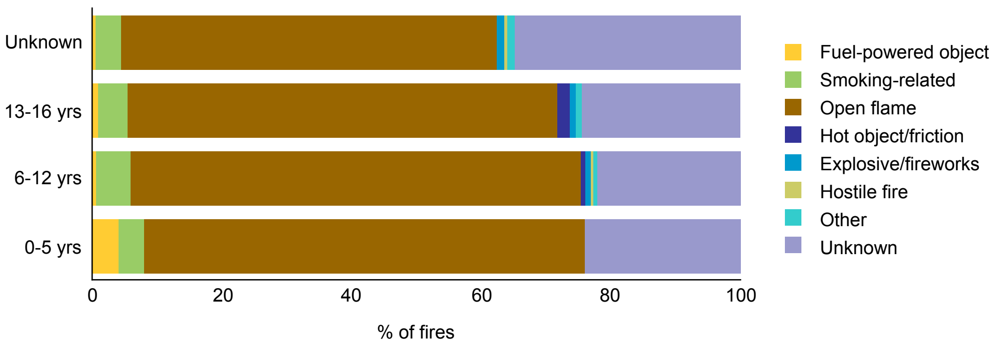
Source: QFRS 1997–98 to 2001–02 [computer file]

Figure 11: Non-deliberate child vegetation fires by age and year



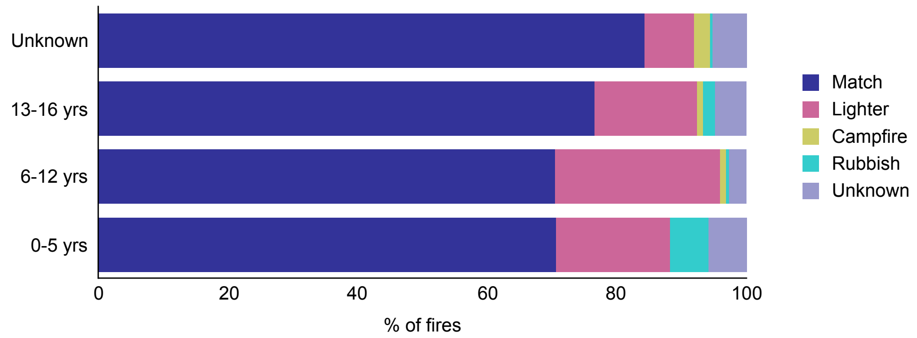
Source: QFRS 1997–98 to 2001–02 [computer file]

Figure 12: Form of heat of ignition by age (percent)



Source: QFRS 1997–98 to 2001–02 [computer file]

Figure 13: Form of heat of ignition by age for cases involving an open flame or spark (percent)

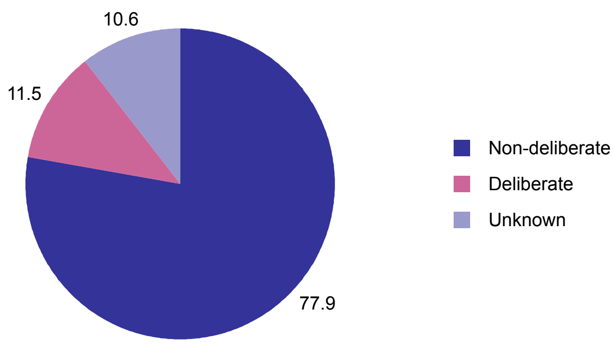


Source: QFRS 1997–98 to 2001–02 [computer file]

Smoking-related fires: The data show that smoking-related materials started 909 fires in the five-year interval, accounting for only two percent of all vegetation fires QFRS attended but 12 percent of cases where the heat of ignition was delineated. In reality the actual figure probably lies somewhere between these two extremes. The lowest rates, based only on those cases where causal attributions were assigned, are likely to underestimate the actual frequency. However, smoking-related fires were likely to have been overrepresented within the 'known' causes owing to more readily identifiable physical evidence. Of the 909 smoking-related vegetation fires 70 percent were attributed to cigarettes. Materials other than cigarettes, cigars or pipes were responsible for 44 vegetation fires (6.5 percent of identified smoking-related fires).

As the smoking-related fires the QFRS attended were identified based on the form of heat of ignition variable, these were potentially classified as deliberate, non-deliberate or unknown. Seventy-eight percent of smoking related fires were identified as non-deliberate, 12 percent deliberate and 11 percent unknown (Figure 14).

Figure 14: Classification of smoking-related fires



Source: QFRS 1997–98 to 2001–02 [computer file]

Location

In this section the distribution of QFRS-attended fires is examined on a region scale, and at a postcode level. Additional analysis is conducted on the distribution of fires relative to population densities. Another section examines the types of complexes where vegetation fires most frequently occurred.

Owing to the low levels of causal attribution, this spatial analysis principally focuses on QFRS-attended vegetation fires collectively rather than examining the deliberate vegetation fires in detail. It is reiterated that the QFRS data is restricted to urban areas where a station is staffed by permanent or part-time staff. Hence, this regional analysis represents the number of vegetation fires that occurred in or near major urban centres within each region rather than the total number of vegetation fires that occurred in each region.

Region

The location of regions used in this analysis is outlined in Figure 15.

All vegetation fires: Approximately half of all QFRS (urban) vegetation fires between 1997–98 and 2001–02 occurred within the Brisbane region (Figure 16). A further eight to 10 percent occurred each in the Gold Coast, Fitzroy, Northern and Tropical North Queensland regions.

Deliberate vegetation fires: The highest proportion of deliberate fires was recorded in the Outback (22%) and Hervey Bay–Maryborough (16%) regions (Figure 16). Nevertheless, it is difficult to accurately compare actual rates of deliberate fires across regions or between urban centres, owing to the low (15 to 37 percent) and variable levels of causal attribution.

When calculated as a proportion of ‘known’ causes, high rates of deliberate fires were evident in all regions that recorded a higher number of vegetation fires generally. Sixty-three percent of fires of known cause in the Outback region were deliberate. This compares with 52 percent for the Gold Coast, 50 percent for Brisbane, 47 percent for the northern region and 43 percent for the Hervey Bay–Maryborough region. In the Fitzroy, Tropical North Queensland, Sunshine Coast, Mackay, Bundaberg and Whitsunday regions deliberate causes accounted for only 25 to 36 percent of known causes. The lowest proportion occurred for the Darling Downs region, where deliberate causes accounted for only 17 percent of fires for cases where the cause of the fire was identified. While these values can be used as a guide, some caution is required in rigorous interpretations owing to the exceptionally low and potentially unrepresentative nature of causal attributions.

Non-deliberate child fires: The number of non-deliberate child fires varied substantially between regions (Figure 17). The highest number occurred in Brisbane, followed by Hervey Bay–Maryborough, Fitzroy, and Coast and Northern regions at substantially lower rates. Overall, there was excellent correlation between the numbers of fires attributed to children and the total number of fires in that region ($r=0.98$; $p<.001$), meaning the proportion of fires attributed to children was broadly constant across regions; however, in detail there were subtle variations.

The highest proportion of child fires occurred in the Hervey Bay–Maryborough region (5.4% of all fires), Whitsunday (4.0%) and Sunshine Coast (3.7%) regions. Higher than ‘predicted’ rates (based on the above correlation) occurred for the Hervey Bay–Maryborough region; and the Gold Coast region recorded lower than predicted values based on total vegetation fire numbers. Whether such variations genuinely reflect regional trends in the number of fires started by children or are an artefact of differences in observation are unclear.

In most regions the numbers of non-deliberate child vegetation fires lit by 6 to 12 year olds were comparable to the numbers lit by 13 to 16 year olds (Figure 18). Exceptions include the Sunshine Coast, Darling Downs and Tropical North Queensland, where 6 to 12 year olds were responsible for greater numbers of non-deliberate fires. Again whether this is a genuine reflection of the actual situation or a sampling bias remains unclear, particularly in light of the high proportion of cases where the age was unknown (Figure 18). The number of vegetation fires accidentally lit by children aged 5 years or younger was low in all regions. The highest numbers were recorded in regional rather than metropolitan areas.

Smoking-related causes were typically responsible for one to three percent of all vegetation fires in any one region (Figure 19). The highest proportions occurred for the Sunshine Coast (3.4%). However, in the Brisbane region, smoking-related materials were responsible for 18 percent of all fires where the heat of ignition was identified (Figure 19). In the majority of regional areas, such fires contributed to seven to 11 percent of known heat of ignitions. Exceptions included the Sunshine Coast region where smoking-related fires contributed to 13 percent of known causes, and the Bundaberg and Outback regions where smoking-related materials only accounted for two to four percent of cases where the heat of ignition was known. Overall, smoking-related causes accounted for a decreasing proportion of all vegetation fires of known cause, with decreasing numbers of smoking-related vegetation fires.

Incendiary devices: Ten cases were recorded of an incendiary device being identified as responsible for a deliberate ignition. Five of these were in the Brisbane region, two in the Fitzroy region, and one each in the Darling Downs, Northern and Outback regions.

Postcode

All vegetation fires: Twenty-one postcodes in Queensland recorded in excess of 500 vegetation fires in five years. Eight were located in the Brisbane region, three in the Northern region, two each in the Fitzroy and Tropical North Queensland regions, and one each in all other regions with the exception of the Sunshine Coast and Whitsunday regions (Table 3; Figure 20). The two postcodes to record in excess of 1,000 fires in five years were located in regional Queensland (Fitzroy and Outback regions). Collectively, the 21 suburbs that recorded in excess of 500 vegetation fires in five years accounted for 34 percent of all vegetation fires the QFRS attended in major urban centres.

Forty-three postcodes recorded between 200 and 499 vegetation fires in five years. The regional distribution of these postcodes is summarised in Table 3. These postcodes were responsible for a further 30 percent of fires. The 60 postcodes that recorded 100 to 199 vegetation fires were responsible for 18 percent of QFRS-attended vegetation fires, with the 125 postcodes recording 25 to 99 vegetation fires accounting for an additional 17.9 percent of fires.

The small number of postcodes that recorded 200 or more fires in five years typically accounted for between 55 and 83 percent of all fires in each region. Although there was one postcode in the Darling Downs region that recorded in excess of 500 vegetation fires in five years, and one postcode in the Sunshine Coast region that had between 200 and 500 vegetation fires, these postcodes accounted for 35 and 20 percent of all fires in those two regions, highlighting the more geographically dispersed nature of the fires.

Table 3: Distribution of fires (all causes) in postcodes within each region

	Brisbane	Gold Coast	Fitzroy	Northern	Tropical North Qld	Outback	Hervey Bay–Maryborough	Sunshine Coast	Darling Downs	Mackay	Bundaberg	Whitsundays
Total no. of fires	20,795	4,629	3,730	3,718	2,621	2,255	1,863	1,654	1,610	1,279	943	404
Total no. of postcodes recording a fire	132	32	20	16	23	34	15	28	46	16	13	4
Number of postcodes recording fires in the following ranges:												
TF ≥ 500	8	1	2	3	2	1	1		1	1	1	
200–499	22	7	4	4	1		3	1				1
100–199	31	7	4	2	5		2	5	1	3		
75–99	20	2		1	2	3		2	3			
50–74	12	3	1	1	2	3	1	2	3	1	2	2
25–49	19	6	2	3	3	4	1	8	8	2	2	1

Regional Queensland: Not surprisingly, given the dataset only included urban data, the highest numbers of vegetation fires in regional areas were generally associated with the largest regional centres in each region. Therefore:

- In the Bundaberg region almost two-thirds of fires occurred in and around Bundaberg.
- In the Darling Downs region, approximately 35 percent of fires occurred in and around Toowoomba, with a further 10 percent occurring in a Warwick postcode.
- Approximately one-third of vegetation fires in the Fitzroy region occurred around Gladstone. Many vegetation fires in the Fitzroy region also occurred around Rockhampton.
- Fires in the Gold Coast region were more evenly distributed across postcodes, perhaps consistent with the more even distribution of the population across that region. However, higher numbers of fires occurred in highly urban areas in the north of region (in what effectively represents the southern extension of the Brisbane metropolitan area) as well in more remote locations of Gold Coast hinterland.
- In the Hervey Bay–Maryborough region almost 65 percent of fires occurred in the postcodes encompassing Hervey Bay, Maryborough and Gympie.
- In the Mackey district, 57 percent of fires occurred in the postcode incorporating Mackay.
- In the Northern region vegetation fires primarily occurred in and around Townsville.
- Two-thirds of fires in the Outback region occurred in and around Mt Isa.
- Fires in the Tropical North Queensland region were principally associated with the postcodes that encompass Cairns (27%) and Mareeba (21%).
- A comparatively small number of vegetation fires occurred on the Sunshine Coast despite a population in excess of 250,000. Individually the greatest number of fires in this region was associated with the Caloundra (20%) and Nambour (10%) postcodes.

Brisbane: Statistical region sectors in the Brisbane region (Figure 21) can be arbitrarily subdivided into four groups based on the distribution of vegetation fires in these regions.

Logan City, Ipswich and Caboolture Shire (Part A) statistical region sectors all record in excess of 2,500 vegetation fires in five years. These statistical region sectors had between one and three postcodes that recorded more than 500 fires in five years, but also from two to four postcodes that recorded between 200 and 499 vegetation fires. In these areas high numbers of vegetation fires were observed across much of the region and postcodes recording in excess of 200 fires in five years accounted for 80 to 100 percent of all fires in the statistical region sectors (Figure 22). All three statistical region sectors are located somewhat distant from the centre of the city, on or close to the fringes of the rapidly expanding metropolitan centre.

The Southern Outer, Northern Outer, Redlands Shire, Pine Rivers Shire and Western Outer statistical region sectors recorded between 1,230 and 2,000 vegetation fires in five years. Greater than 500 vegetation fires were only recorded within one postcode each in the Pine Rivers Shire and Western Outer statistical region sectors. Only 53 to 68 percent of fires within individual statistical region sectors occurred in postcodes recording in excess of 200 fires. Between 82 and 92 percent of all vegetation fires in these regions occurred in postcodes recording in excess of 100 vegetation fires in five years (Figure 22).

In statistical region sectors that recorded between 317 and 1,202 vegetation fires in five years (North and West Moreton sectors, Eastern Outer, Redcliffe City and Eastern Inner sectors), greater than 200 vegetation fires were only evident in one postcode each in the North and West Moreton and the Eastern Outer sectors. Postcodes recording in excess of 100 vegetation fires in five years accounted for 57 to 63 percent of all vegetation fires in individual sectors (Figure 22).

Statistical region sectors in the inner metropolitan area, including the Northern Inner, City Core, Western Inner and Southern Inner sectors, recorded low numbers of vegetation fires (less than 300) in five years. The maximum number recorded in any one postcode was between 75 and 99 for all but the Northern Inner sector, where the maximum was between 50 and 75 vegetation fires.

In summary, high frequencies of fires tend to occur in geographically restricted areas that are located on the outer margins of Brisbane metropolitan area, whereas inner city areas are characterised by low numbers of vegetation fires. The maximum number of fires recorded in a postcode tended to be greatest in those statistical region sectors that, overall, recorded the highest numbers of vegetation fires. Rarely were high numbers of vegetation fires restricted to a single postcode. In sectors recording high numbers of fires, many postcodes record elevated numbers of vegetation fires, and postcodes recording high numbers of vegetation fires account for a large proportion of all vegetation fires in that statistical region sector. The maximum number of vegetation fires recorded in a single postcode, and the proportion of vegetation fires hosted within high fire frequency postcodes, overall, declines as the number of vegetation fires recorded in the statistical region sectors decreases.

Deliberate fires: Only one postcode recorded in excess of 450 deliberate fires, three reported 100 to 110 deliberate fires, 17 documented 50 to 99, and 25 postcodes had 25 to 49 deliberate fires in five years. However, the low levels of causal attribution limit the accuracy and usefulness of such results. The findings from other agencies and jurisdictions are that the highest number, and commonly the highest proportion, of deliberate fires tend to occur in those areas that record the greatest number of vegetation fires generally. This remains to be evaluated for the QFRS data, but is likely to provide a useful guide for arson reduction strategies in Queensland.

Population analysis

This analysis examines the distribution of fires relative to population densities within individual postcodes. It is necessarily, due to the low levels of causal attributions, to restrict the discussion to vegetation fires generally rather than examine deliberate fires specifically.

There is a strong tendency for the number of fires to increase with increasing population size (Figure 23). Although the maximum rate of fires per 10,000 people tended to decrease with increasing population, overall, the rates tend to be broadly similar across highly varying population densities. Most postcodes, whether they contained 1,000 or 50,000 people, recorded between one and 100 vegetation fires per 10,000 people per year (Figure 24).

In the Brisbane region, the highest rates of fires per 10,000 people per year occurred in a small number of postcodes that had small resident populations, but were likely accessed or used by the larger surrounding or visiting population, for example, Karawatha, Eagle Farm, Pinkenba and Rocklea. A higher proportion of fires per person also occurred for one postcode in the Gold Coast hinterland. It is unclear whether this reflects inaccurate population data (ABS data indicates 660 people), a high influx of visitors, or other factors. Although this Gold Coast postcode only recorded 34 fires in five years, it is noted that unplanned fires (depending on severity and location) are potentially of concern to preserving the Eastern Bristlebird, an endangered species in the region (QPWS 2001).

The results, on a per-person basis, are most significant for postcodes with higher populations, as these are less likely an artefact of statistical anomalies resulting from a small resident but potentially large migratory population. Postcodes that have both high resident populations with a high rate of fires per person, particularly as compared with other postcodes in the region, include single postcodes in the Mount Isa (Outback region), Mount Morgan (Fitzroy region), Murgon (Hervey Bay–Maryborough region) and Mareeba (Tropical North Queensland region) statistical local areas.

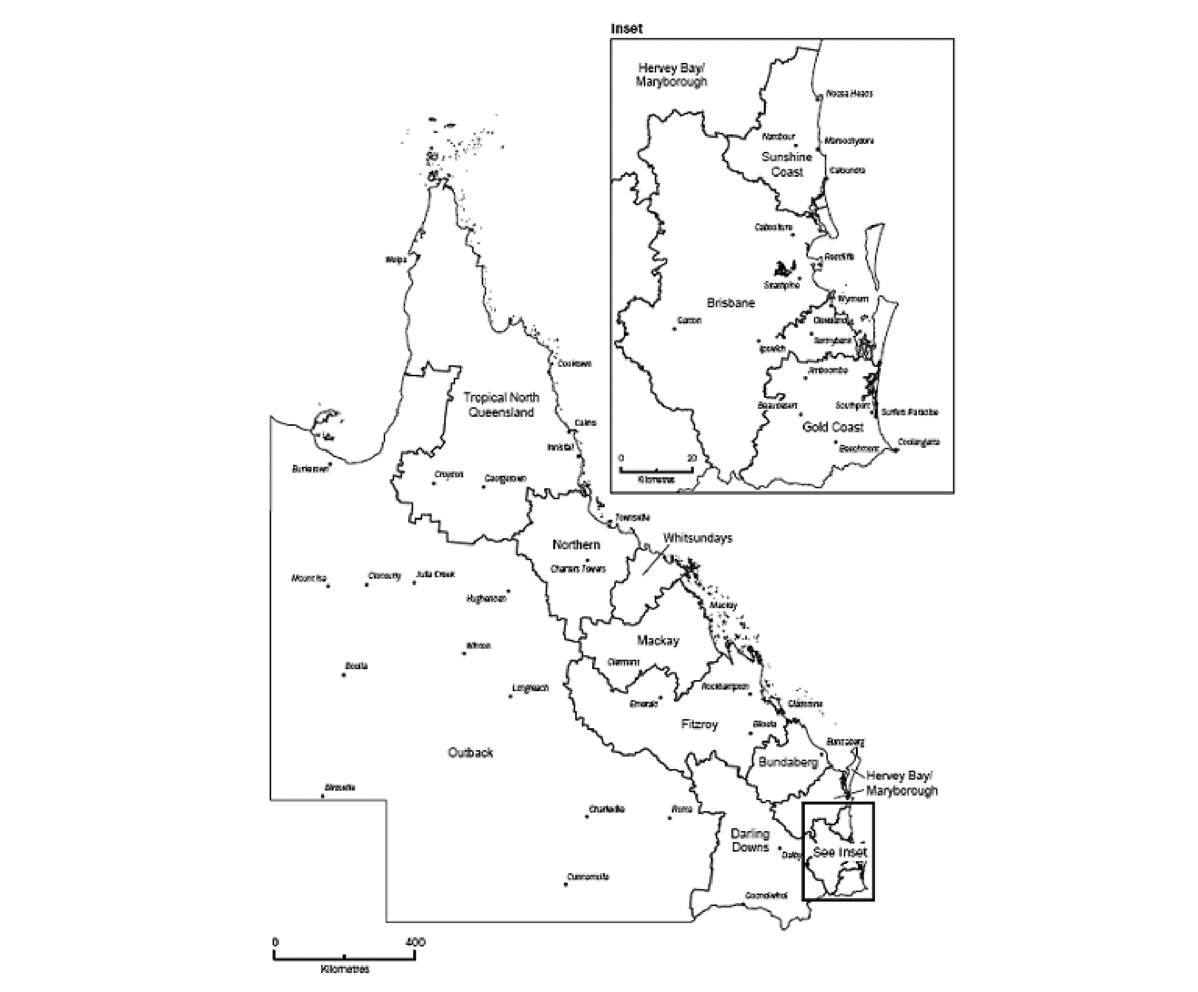
Although there is considerable overlap, there is some tendency for postcodes in regional areas to be characterised by lower rates of fires per person. In some cases this may reflect the fact that data for rural postcodes are incomplete as the QFRS data analysed does not incorporate rural fire service data. However, given this is also witnessed in postcodes with large population densities (where inclusion of rural data would only have a small affect), it is possible that regional areas in Queensland are genuinely characterised by low numbers of fires per person.

Complex

The majority of vegetation fires the QFRS attended in urban locations occurred on unused property or Crown land. Other important locations included parks, forests, reserves, road complexes (roads, tracks, parking lots, etc.), followed by single dwellings, farms, and construction/demolition sites and railroads (Figure 25). The rates of causal attribution varied between these various complex types. Deliberate causes comprised the highest proportion of fires (50 to 60%) on unused property or Crown land, parks, forests and reserves, but also at public recreation complexes, schools, marinas and piers (Figure 25). Comparatively fewer vegetation fires along road complexes or at single dwellings, farms or construction sites were identified as deliberate (15 to 35% of known attributions).

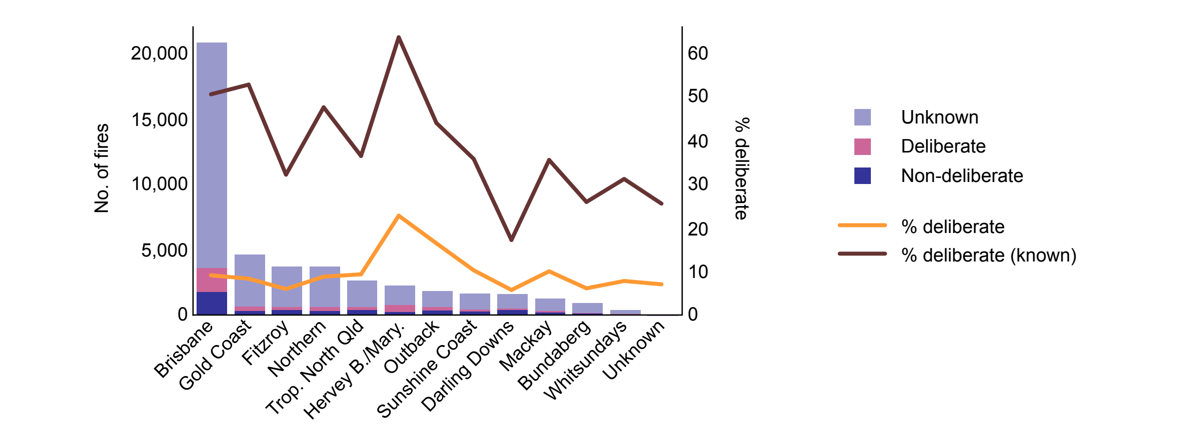
The general distribution of non-deliberate child vegetation fires paralleled that observed for vegetation fires generally. Namely, the majority of all vegetation fires accidentally lit by children were greatest for unused property or Crown land, parks, forests and reserves, road complexes and single dwellings. Subtle differences are evident between age groups (Figure 26). A comparatively high proportion of fires lit by children five years and younger occurred at single dwellings. Fires at these locations comprise a progressively smaller proportion of non-deliberate fires for older age groups. The range of locations where children light fires also became more diverse as children become older.

Figure 15: Tourism regions of Queensland



Source: ABS 2005b

Figure 16: Region, by cause[a,b]

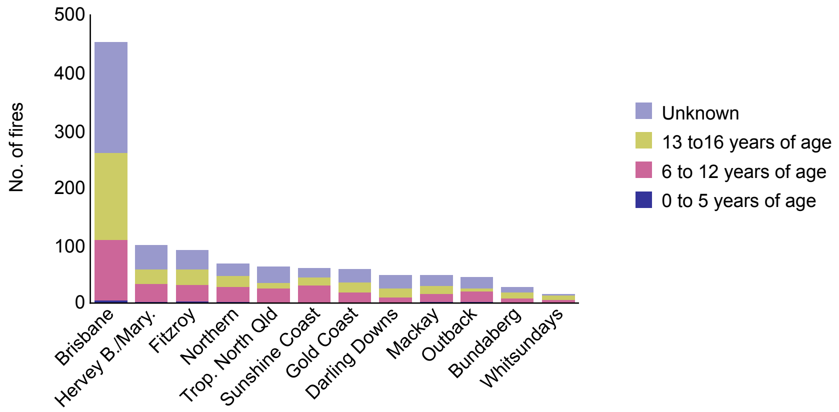


a: % deliberate (known) is the percentage of fires of known causes that were deliberate

b: Hervey B./Mary. = Hervey Bay/Maryborough; Trop. North Qld = Tropical North Queensland

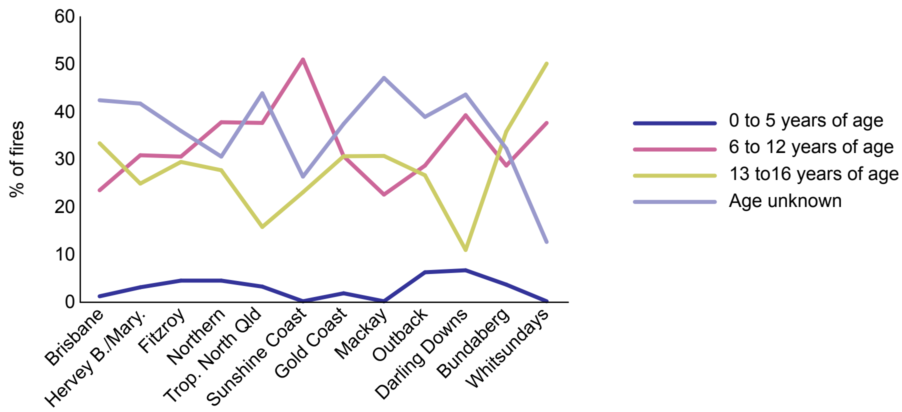
Source: QFRS 1997–98 to 2001–02 [computer file]

Figure 17: Non-deliberate child fires, by region (number)



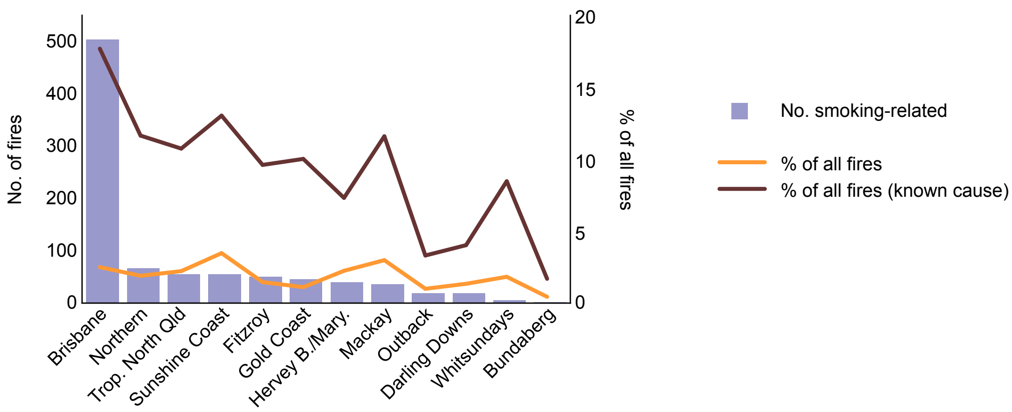
Source: QFRS 1997–98 to 2001–02 [computer file]

Figure 18: Non-deliberate child, by age group and region (percent)



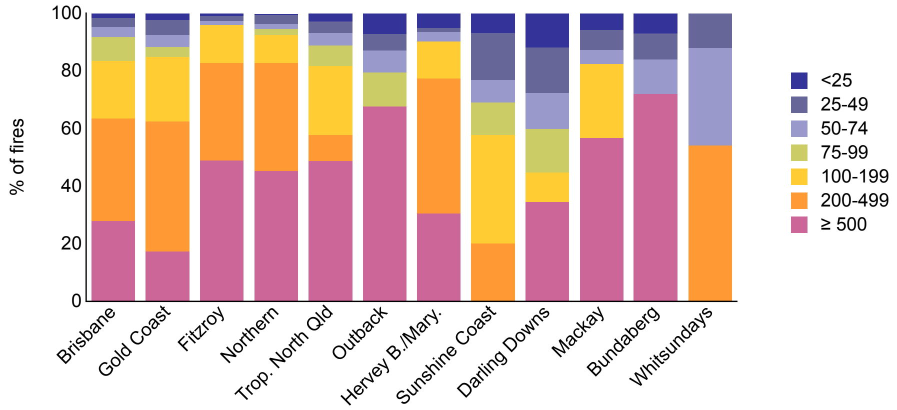
Source: QFRS 1997–98 to 2001–02 [computer file]

Figure 19: Smoking related fires, by region



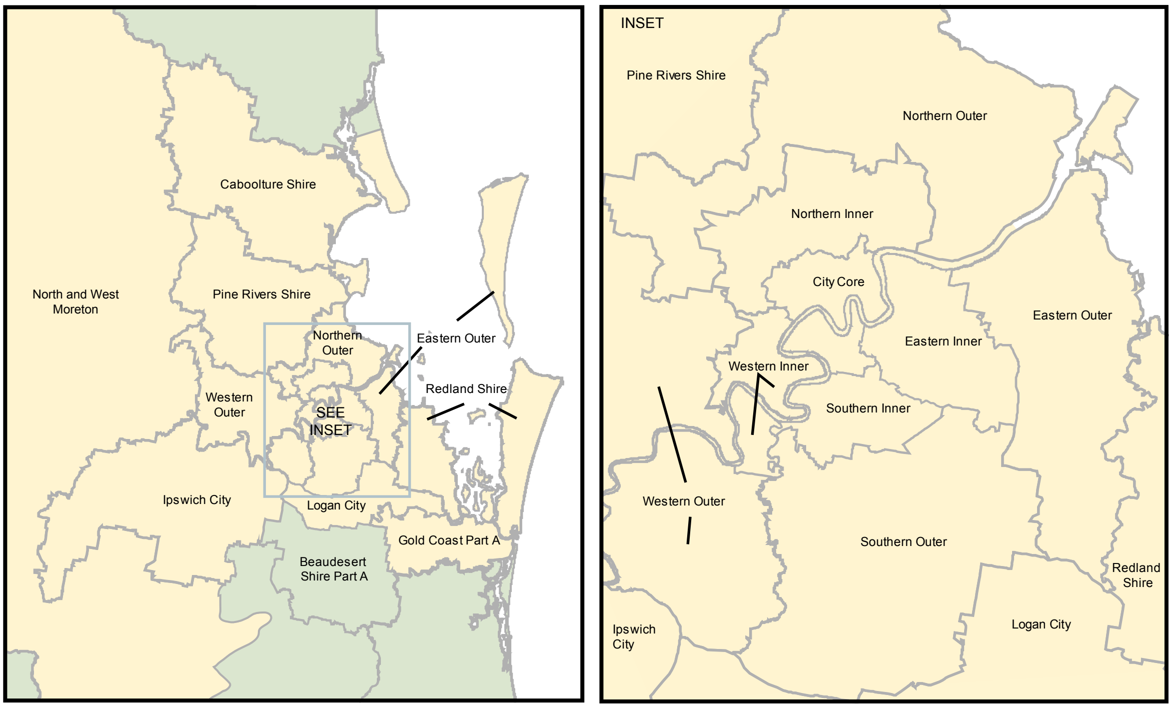
Source: QFRS 1997–98 to 2001–02 [computer file]

Figure 20: Fires occurring in postcodes with total fire frequencies in the specified ranges, by region (percent)



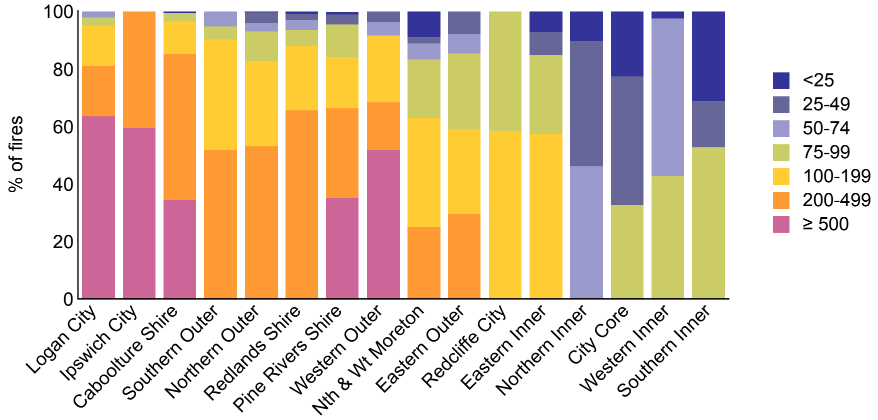
Source: QFRS 1997–98 to 2001–02 [computer file]

Figure 21: Statistical region sectors in southeast Queensland



Source: ABS 2006b

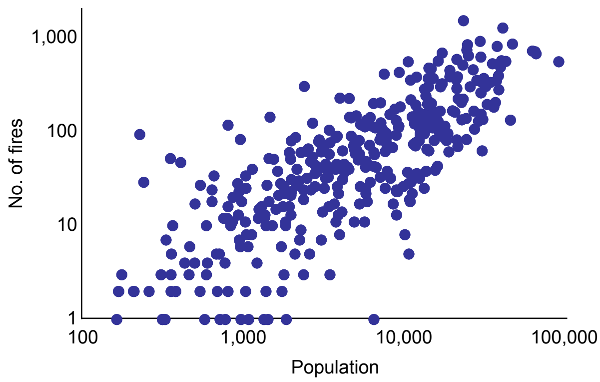
Figure 22: Fires occurring in postcodes with total fire frequencies in the specified ranges, by statistical region sectors[a] in the Brisbane region (percent)



a: Ipswich City = Ipswich City (Part B in BSD); Caboolture Shire = Caboolture Shire (Part A); Nth & Wt Moreton = North and West Moreton

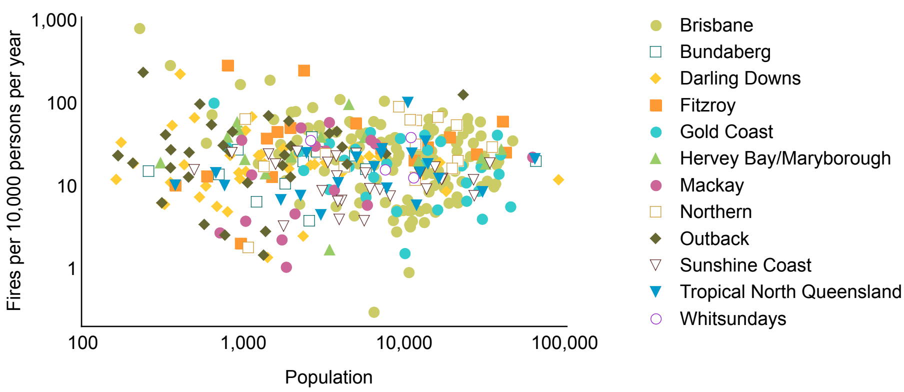
Source: QFRS 1997–98 to 2001–02 [computer file]

Figure 23: Fires and population, by postcode



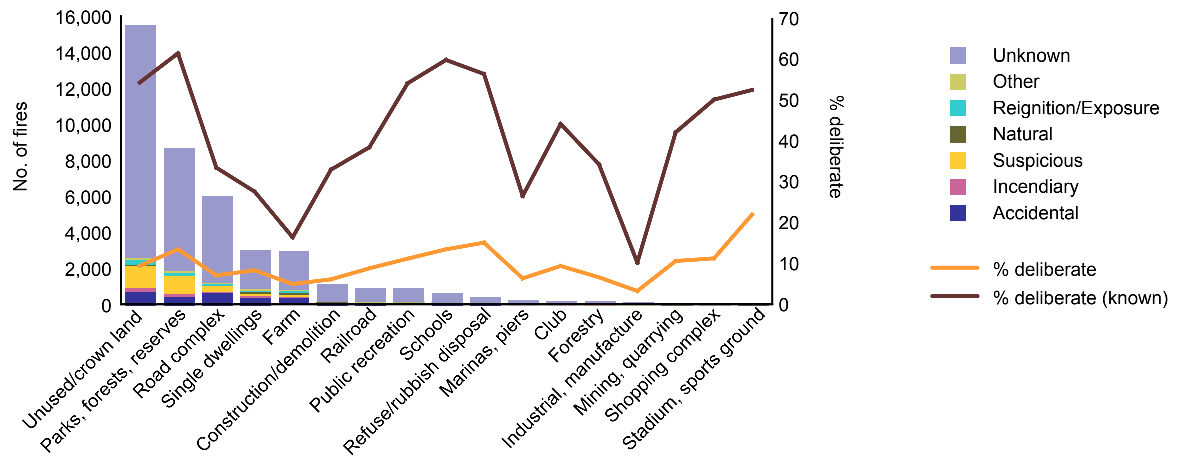
Source: QFRS 1997–98 to 2001–02 [computer file]; ABS 2004. Population by post office area, 2001 [computer file]

Figure 24: Postcodes within each region, by fires per 10,000 people and population



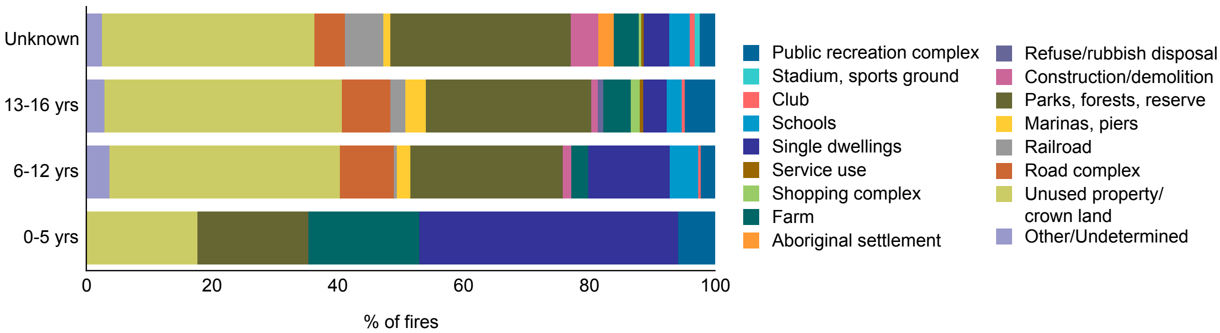
Source: QFRS 1997–98 to 2001–02 [computer file]; ABS 2004. Population by post office area, 2001 [computer file]

Figure 25: Complex type, by cause



Source: QFRS 1997–98 to 2001–02 [computer file]

Figure 26: Non-deliberate child fires lit at complex type for child's age (percent)[a]



a: Other/undetermined includes a single fire lit by a 6 to 12 year old at a communication use complex and a child day care complex; a single fire lit by 6 to 13 year old at an apartment complex; a single fire lit by child of unknown age each at a forestry complex, and medical care complex

Source: QFRS 1997–98 to 2001–02 [computer file]

Timing

The timing of fires is examined by week of the year, day of the week and time of the day.

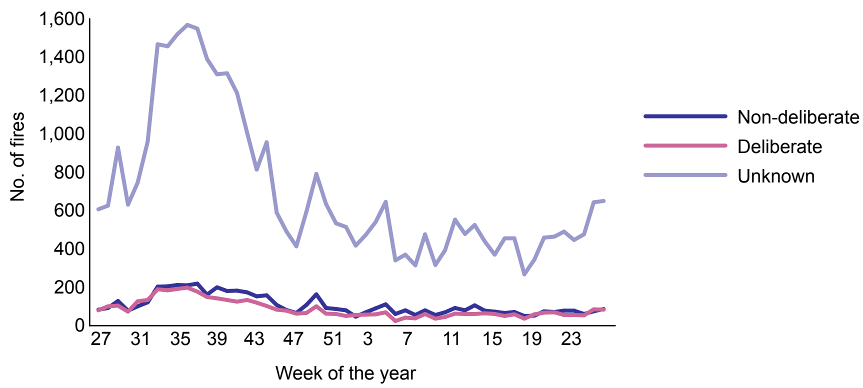
Week of the year

The QFRS attended peak numbers of fires in late winter and spring irrespective of cause (Figure 27), although the number of fires attended in any one week, and the length of time over which elevated numbers of fires occurred, varied considerably between seasons (Figure 28). The highest number of fires recorded in any one week occurred in 2001–01, when 1,015 vegetation fires were attended during week 36 (early August). Nevertheless, an elevated number of fires occurred over a comparatively short period (approximately 10 weeks). In contrast, during 2001–02, four distinct smaller peaks occurred over a 17-week period.

Most fires the QFRS attended during the reporting period occurred in southeast Queensland. There are some subtle regional differences in the timing, length and intensity of the bushfire season. For example, the Brisbane (Figure 29) and Gold Coast (Figure 30) regions experienced a high frequency of fires during a particularly short interval in late winter and spring, whereas fires in the Northern region occurred over an extended period and the activity during any one week was typically less intense when compared to background levels (Figure 29). In the Outback (principally Mount Isa) region, fire numbers steadily increased from March onwards, peaked in late winter, before subsequently dropping off sharply. This pattern is typical of the fire regimes of the tropical savannas, in northern Australia.

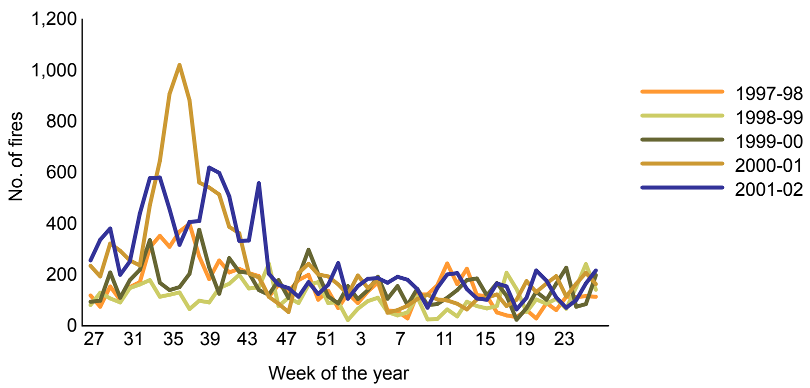
A number of regions recorded a small increase in the number of fires during weeks 50 and 4. This spike is particularly evident for fires that resulted from an open flame (Figure 31), but this heat of ignition factor is not a definitive guide to the deliberate or non-deliberate nature of the fires. There is no definitive cause for increased fire frequencies at these times, although it is noted that the timing of the two spikes roughly coincides with the end and resumption of the school year respectively. Fires caused by abandoned or discarded materials were highest during the peak bushfire period but remained comparatively elevated until the end of March (Figure 31). Children accidentally lit the greatest number of fires during the greatest period of bushfire danger, with comparatively smaller numbers being recorded for the Christmas school holiday period (Figure 32).

Figure 27: All vegetation fires, by week of the year, by cause



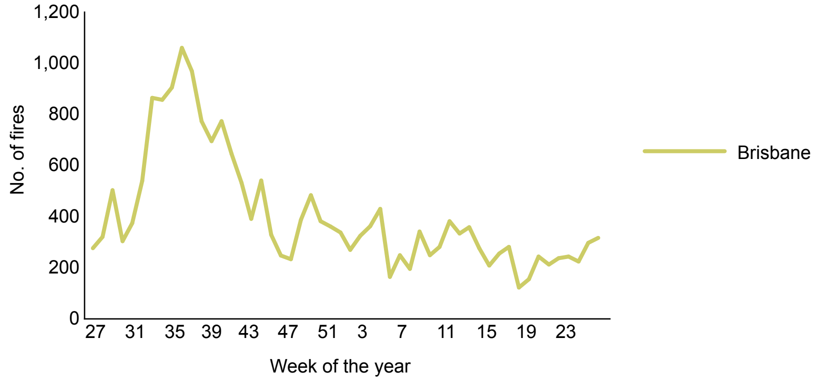
Source: QFRS 1997–98 to 2001–02 [computer file]

Figure 28: All vegetation fires, by week of the year, by year



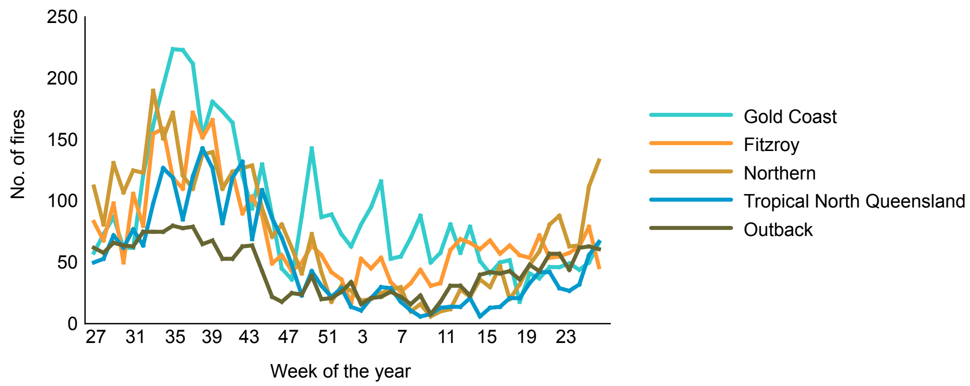
Source: QFRS 1997–98 to 2001–02 [computer file]

Figure 29: All vegetation fires, by week of the year for Brisbane region



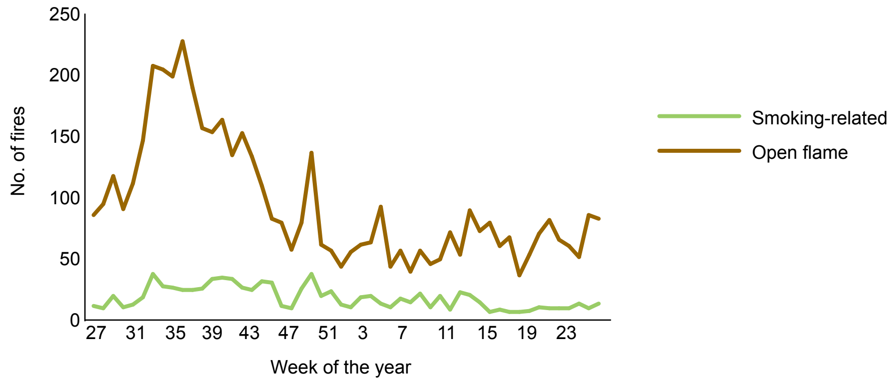
Source: QFRS 1997–98 to 2001–02 [computer file]

Figure 30: All vegetation fires, by week of the year for other regions



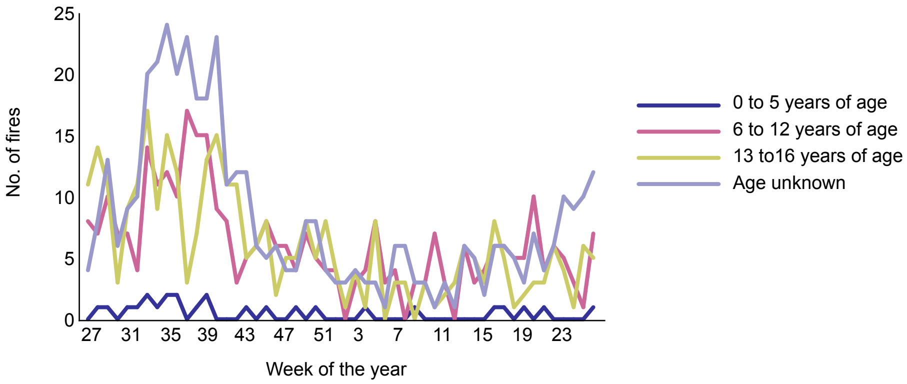
Source: QFRS 1997–98 to 2001–02 [computer file]

Figure 31: Abandoned/discarded material and open flame/spark fires, by week of the year



Source: QFRS 1997–98 to 2001–02 [computer file]

Figure 32: Non-deliberate child fires, by age and week of the year



Source: QFRS 1997–98 to 2001–02 [computer file]

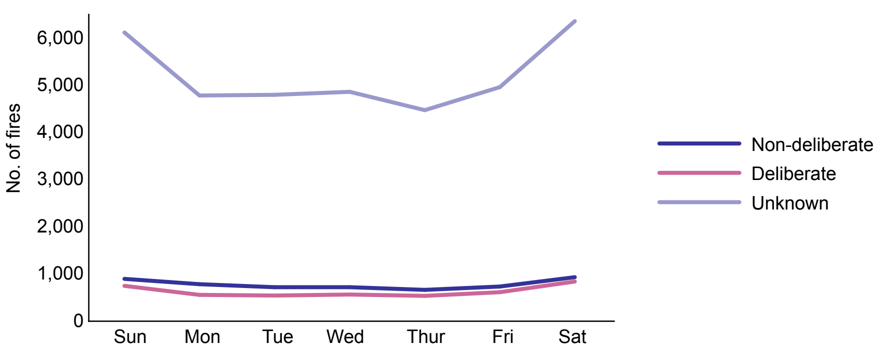
Day of the week

The QFRS attended 28 percent more vegetation fires on Sunday and 35 percent more fires on Saturday than on the average weekday. This was observed for non-deliberate, deliberate and unknown fires (Figure 33). However, for deliberate causes 35 and 52 percent more fires occurred on Sunday and Saturday respectively. This is somewhat higher than for non-deliberate fires where only 25 to 29 percent more fires occurred on a weekend day than on a weekday.

A higher incidence of vegetation fires on weekends was observed in all areas except the Whitsunday region. Comparatively higher proportions of fires on weekends occurred in the Mackay, Bundaberg and Darling Downs regions. In the Mackay area, 49 percent more fires occurred on Saturdays and 60 percent more fires occurred on Sundays than on the average weekday. For Bundaberg, these values were 37 and 67, respectively. For the Darling Downs region, 35 percent more fires occurred on Saturdays and 44 percent on Sundays relative to the average weekday.

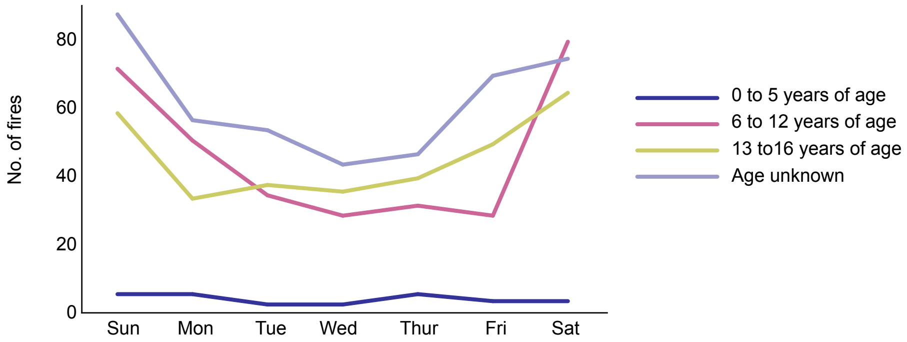
Overall, non-deliberate child vegetation fires were 70 percent higher on weekend days than on the average weekday. Increased numbers of fires were observed on weekends for all groups except the zero to five year old age group. Six to 12 year olds lit between 2.1 and 2.3 more fires on Sunday and Saturday than on the average weekday (Figure 34). The values were 1.5 and 1.7 times higher on Sunday and Saturday for 13 to 16 year olds.

Figure 33: Day of the week, by cause



Source: QFRS 1997–98 to 2001–02 [computer file]

Figure 34: Non-deliberate child fires, by age and day of the week



Source: QFRS 1997–98 to 2001–02 [computer file]

Time of the day

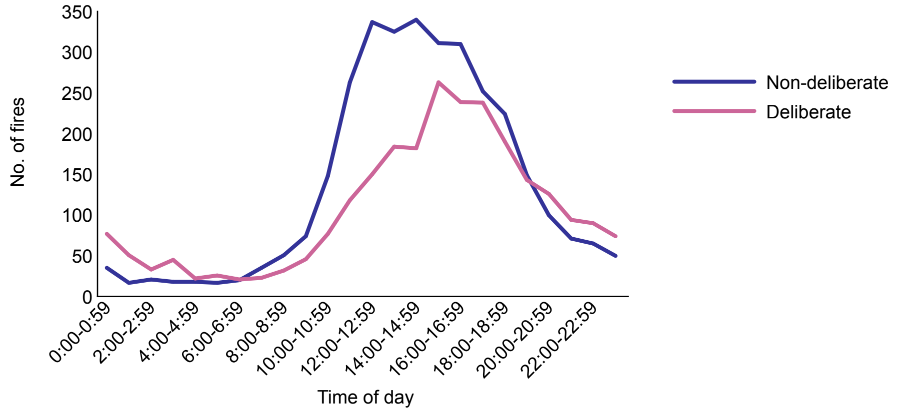
The QFRS attended the greatest number of fires between 9 am and 9 pm, with peak numbers occurring between 3 and 4 pm. Within the 13 percent of all fires where both cause and time were delineated, subtle differences were evident between the timing of deliberate and non-deliberate related fires (Figure 35). Deliberate vegetation fires lit during the day have a skewed distribution, whereas non-deliberate fires more closely resemble a normal distribution. Hence, although the frequencies for both deliberate and non-deliberate fires increased from 10 am onwards, the greatest number of deliberate fires occurred between 3 and 6 pm, whereas for non-deliberate fires the peak was between 12 and 3 pm. Also, as noted in other jurisdictions, a greater number and proportion of deliberate fires occurred at night as compared with non-deliberate fires. Thirty-seven percent of deliberate fires occurred between 6 pm and 6 am as compared to 24 percent for non-deliberate fires. However, the proportion of deliberate fires the QFRS attended between midnight and 6 am was comparatively low when compared to many other jurisdictions, with only 9 percent of deliberate fires (where both time and cause were known) occurring within this timeframe.

Subtle variations were evident in the timing across different regions. In approximately 10 percent of cases information about both the cause and time were known for fires in the Brisbane region. Overall, the timing of fires in the Brisbane region mirrored the general trend QFRS outlined above (compare Figure 35 and Figure 36). Fires between 6 pm and 4 am in the Brisbane region were marginally more likely to occur on Friday night–Saturday morning and Saturday night–Sunday morning than on other nights of the week. This was particularly evident for the 8 to 9 pm interval on Saturday night.

A high proportion of fires in the Outback region occurred at night when compared with many other areas of the state (Figure 37); 44 percent occurred between 6 pm and 6 am (Figure 38). This was more evident for deliberate than for non-deliberate causes; 51 percent of deliberate fires occurred between 6 pm and 6 am whereas only 31 percent of non-deliberate fires occurred in this timeframe. If these distributions are generally representative of deliberate and non-deliberate fires, roughly two-thirds of the fires of unknown origin in the Outback region may have been deliberate in origin. This is similar to the proportion of deliberate fires calculated based on ‘known’ causes alone. Seventeen percent of deliberate fires in the Outback region occurred between midnight and 6 am compared to a value of five percent for non-deliberate fires. Fires that occurred between midnight and 6 am in the Outback region were more frequent on Saturday and Sunday mornings than on any other day of the week. Fire frequencies spike between 7 and 8 pm for both Mondays and Saturdays. As for the Brisbane region, the daytime peak for deliberate fires occurred somewhat later than non-deliberate fires, with the greatest frequency of deliberate fires in the Outback region occurring between 4 and 5 pm (Figure 38).

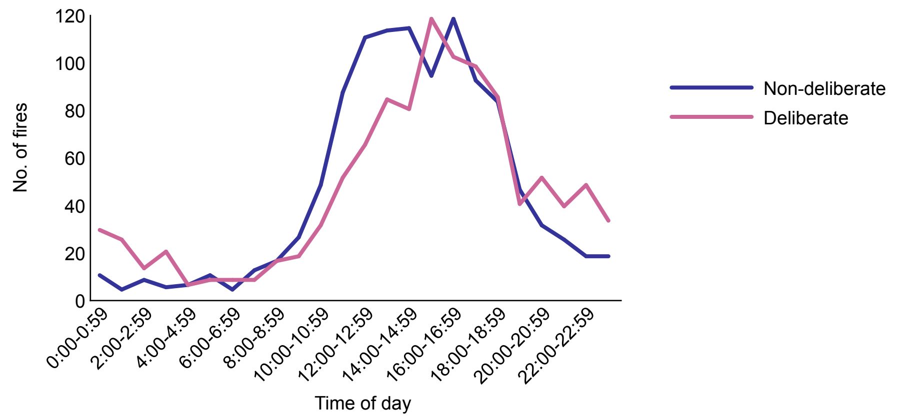
Non-deliberate fires attributed to children primarily occurred during the day. The distribution is skewed with peak numbers occurring between 4 and 6 pm (Figure 39). This distribution is observed for both 6 to 12 year olds and 13 to 16 year olds. This distribution is similar to that observed for deliberate daytime fires generally.

Figure 35: Time of day, by cause



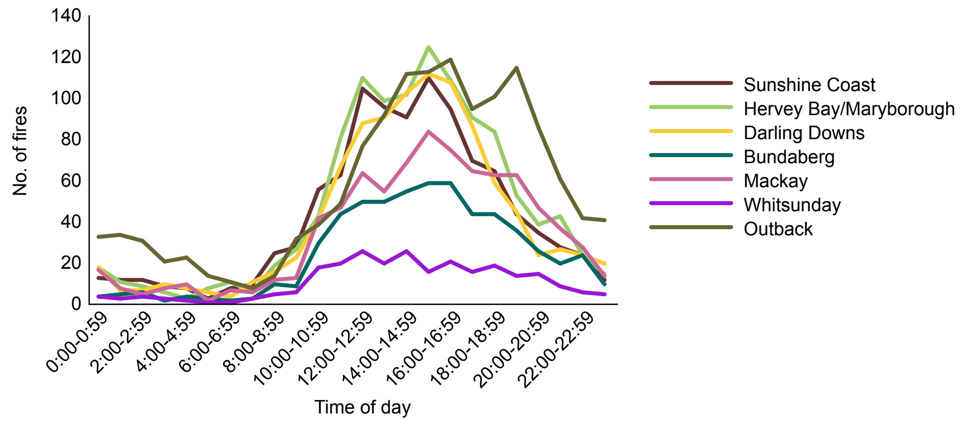
Source: QFRS 1997–98 to 2001–02 [computer file]

Figure 36: Time of day, by cause for the Brisbane region



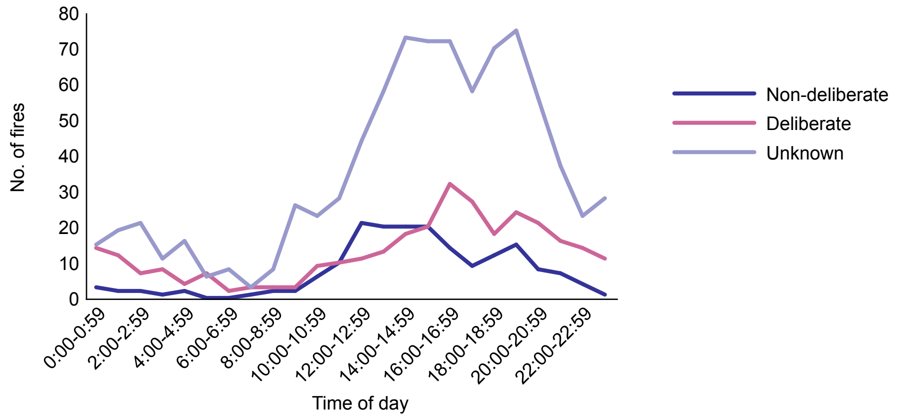
Source: QFRS 1997–98 to 2001–02 [computer file]

Figure 37: All vegetation fires, by time of day, by region



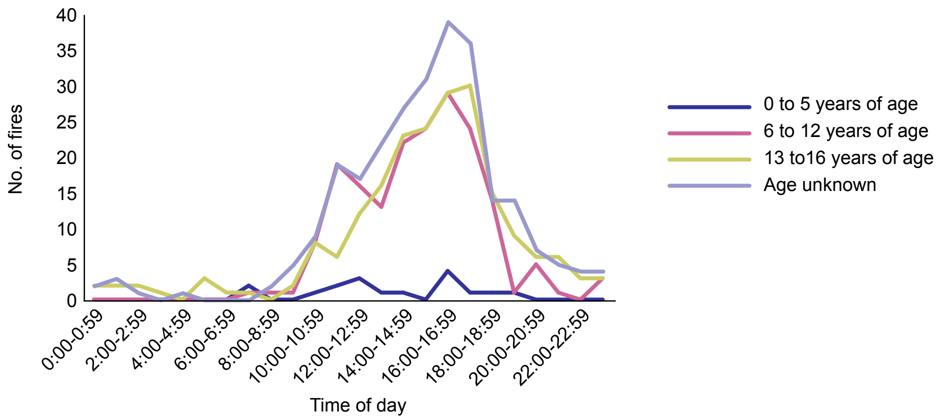
Source: QFRS 1997–98 to 2001–02 [computer file]

Figure 38: Time of day, by cause for the Outback region



Source: QFRS 1997–98 to 2001–02 [computer file]

Figure 39: Non–deliberate child fires, by age and time of day



Source: QFRS 1997–98 to 2001–02 [computer file]

Area burned

Data about the area burned between 1997–98 and 2003–04 was available in 94 percent of cases. Collectively, the area burned amounted to 2,166,640 ha. However, information about the area burned and cause were only available for 19.4 percent of fires.

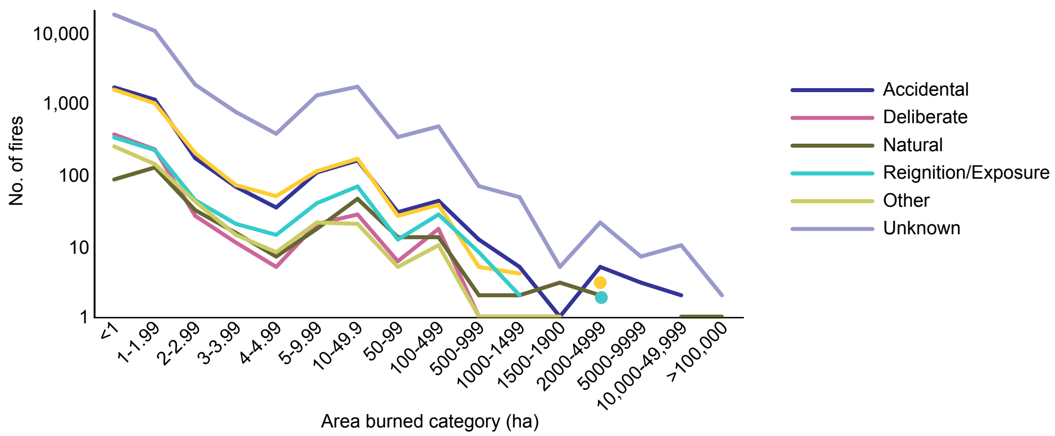
The number of fires decreased sharply with increasing area burned, irrespective of the cause (Figure 40). Collectively, deliberate fires accounted for a decreasing proportion of fires with increasing area burned. The majority of larger fires resulted from natural or accidental causes (Figure 41).

The largest identified deliberate fire burned 1,500 ha. However, one fire labelled suspicious burned 12,000 ha. In contrast, the largest natural fire in this period burned 250,000 ha. The cause of the largest recorded fire, which burned 1,000,000 ha, was unknown. However, caution is needed when interpreting these results due to the small proportion of cases where cause was attributed and the markedly variable fire sizes across the state; fire size depended on the environment, accessibility, resources available for suppression, and potential threat to life and property. Potential ecological benefits of a fire also need to be considered when interpreting the data. Nevertheless, the observation that deliberate fires tended to be smaller than natural fires is consistent with the trend observed in many jurisdictions in Australia.

The area burned annually varied substantially, primarily because of the distribution of a small number of large-scale events. The greatest area of land burned during the five-year interval surveyed occurred during the season of 1998–99, when a fire of unknown cause burned 1,000,000 ha in Tropical North Queensland (Figure 42). Given this, it is not surprising that unknown attributions accounted for the greatest area burned. Fires of unknown cause accounted for 80 percent of the total area burned in fires the QFRS attended (Figure 43). Of the fires where cause was known, natural fires were the largest contributor (66% of known) followed by accidental fires (17% of known; Figure 44). Incendiary and suspicious fires accounted for 1.6 and 9.7 of fires where cause was attributed, respectively.

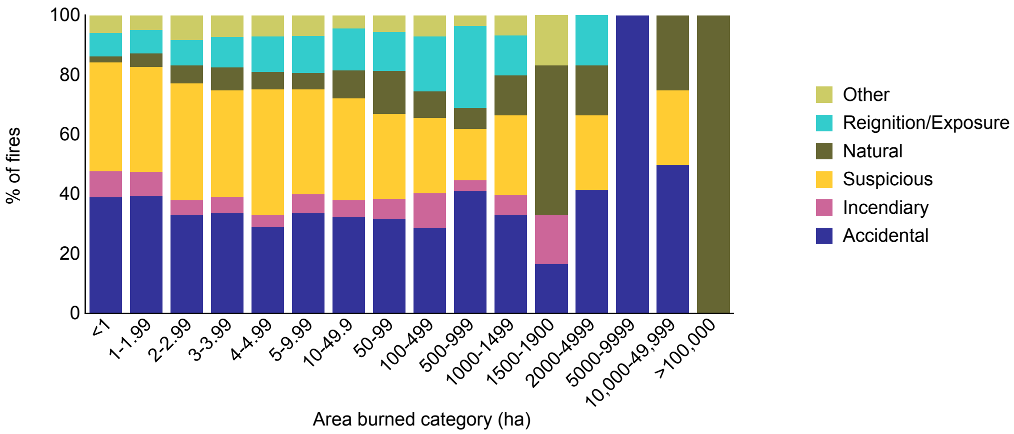
The largest areas were burned in those areas that experienced the largest fires, namely Tropical North Queensland, the Outback, Mackay, and the Northern regions. Although almost 50 percent of all fires the QFRS attended occurred in the Brisbane region, these fires accounted for less than five percent of the area burned in Queensland between 1997–98 and 2001–02. Nevertheless, approximately 107,000 ha of land burned in the Brisbane region during this interval. The largest deliberate fire, the 12,000 ha fire noted above, occurred near Ipswich, in the Brisbane region. Seventeen fires in the Brisbane region exceeded 1,000 ha of which four were suspicious in origin. These principally occurred to the north of Ipswich and to the west of Caboolture. A total of 333 fires in the Brisbane region exceeded 50 ha. Thirty-four of these were in the Caboolture area. Only 31 of the 333 fires exceeding 50 ha were incendiary or suspicious in origin. The cause of 265 fires of the greater than 50 ha was unknown.

Figure 40: Area burned (ha) category, by cause (number)



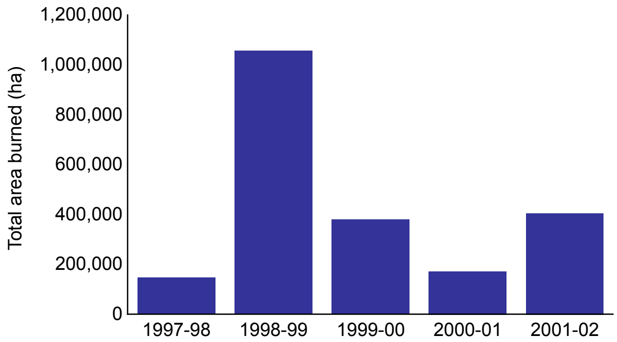
Source: QFRS 1997–98 to 2001–02 [computer file]

Figure 41: Area burned (ha) category, by cause (percent)



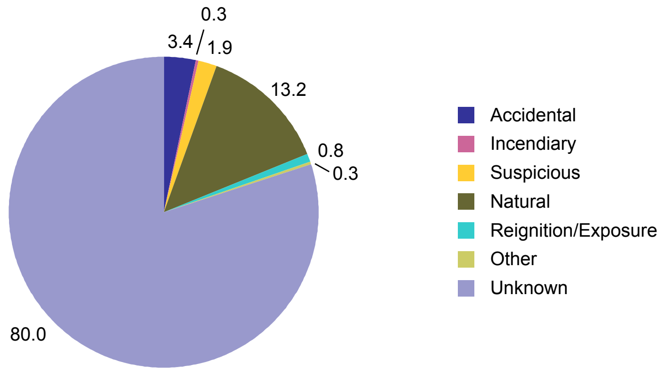
Source: QFRS 1997–98 to 2001–02 [computer file]

Figure 42: Area burned (ha) each year



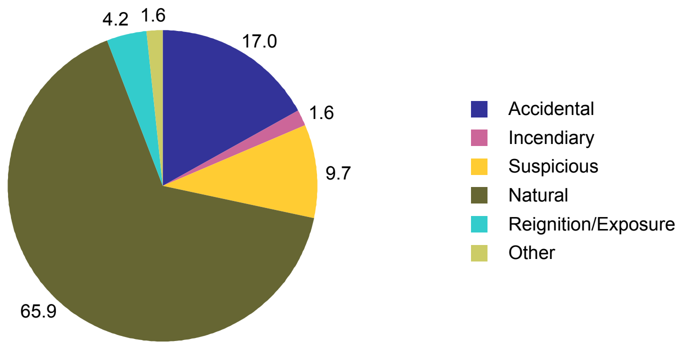
Source: QFRS 1997–98 to 2001–02 [computer file]

Figure 43: Area burned (ha), by cause



Source: QFRS 1997–98 to 2001–02 [computer file]

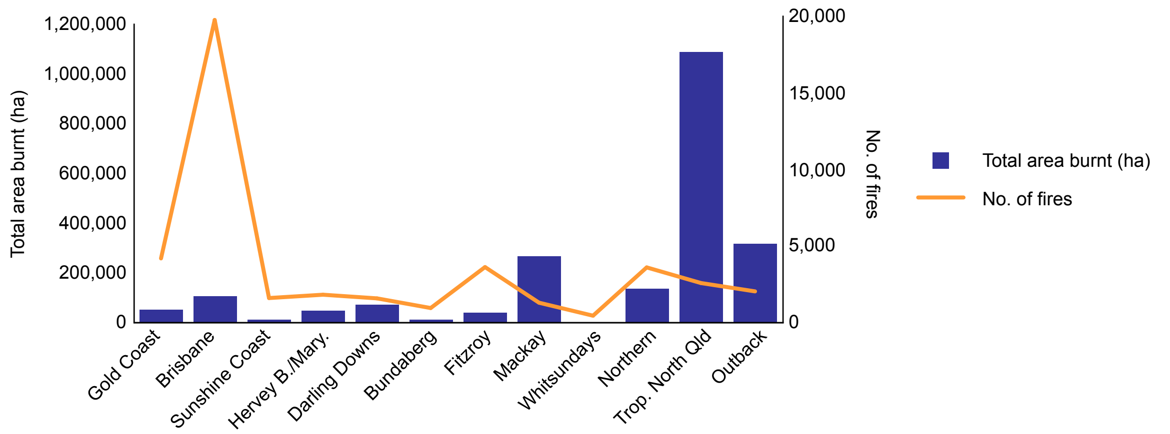
Figure 44: Area burned (ha), by cause[a]



a: only includes the 19.4 percent of cases where both cause and area were known

Source: QFRS 1997–98 to 2001–02 [computer file]

Figure 45: Region, by number of fires and area burned



Source: QFRS 1997–98 to 2001–02 [computer file]

Type of incident

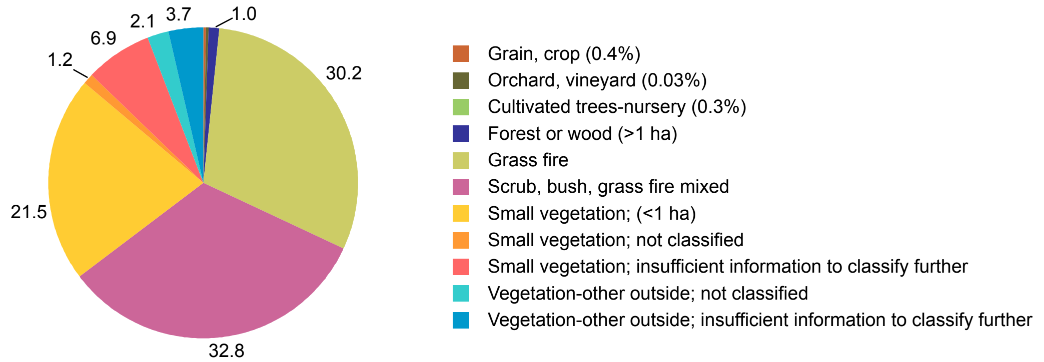
Twenty-two percent of all fires QFRS urban services attended were small vegetation fires of less than one hectare in size (Figure 46). A further eight percent were small vegetation fires that were either not classified or there was insufficient information to classify. Thirty percent of all fires were grass fires with another 33 percent of fires occurring in scrub, bush or mixed grass environments. Only one percent of all fires attended were forest or wood fires greater than one hectare.

The cause of the fires was more likely to have been determined for fires occurring in orchards, vineyards and nurseries (53%), and grain or crop fires (43%) than for any other incident type. The lowest rates of causal attributions occurred for scrub, bush and grass mixed fires (14%) and for grass fires (18%).

Deliberate causes accounted for 38 and 57 percent of known causes for all incident types except grain and crop fires (Figure 47). The highest rates of deliberate fires (as a percent of known causes) occurred for fires in orchards, vineyards and nurseries (57%), scrub, bush and grass mixed fires (54%), and for forest and wood fires greater than one ha (47%). In comparison, only 43 percent of small vegetation fires and 40 percent of grass fires were considered deliberate in instances where cause of the fire was assigned.

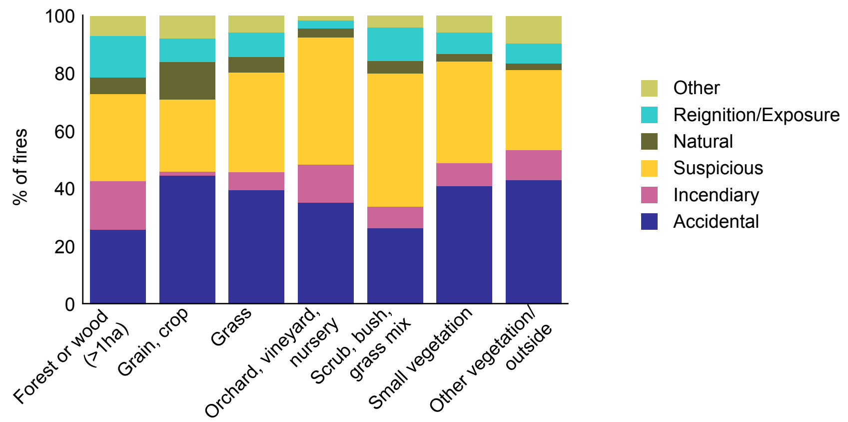
The proportion of vegetation fires classified as small vegetation fires was comparatively uniform across all regions, excluding Tropical North Queensland and to a lesser extent the Sunshine Coast regions, where there were higher proportions of small vegetation fires (Figure 48). Similarly, the combined proportions of grass fires and scrub, bush and grass mixed fires were comparatively uniform across most regions, although in detail the ratio of these vegetation types varied; the Gold Coast and Brisbane regions recorded more scrub, bush and grass mixed fires, whereas the Fitzroy, Northern, Darling Downs and Hervey Bay–Maryborough regions recorded a higher proportion of grassfires. This likely reflects different vegetation distributions in or near major urban centres in these regions.

Figure 46: Type of incident (percent)



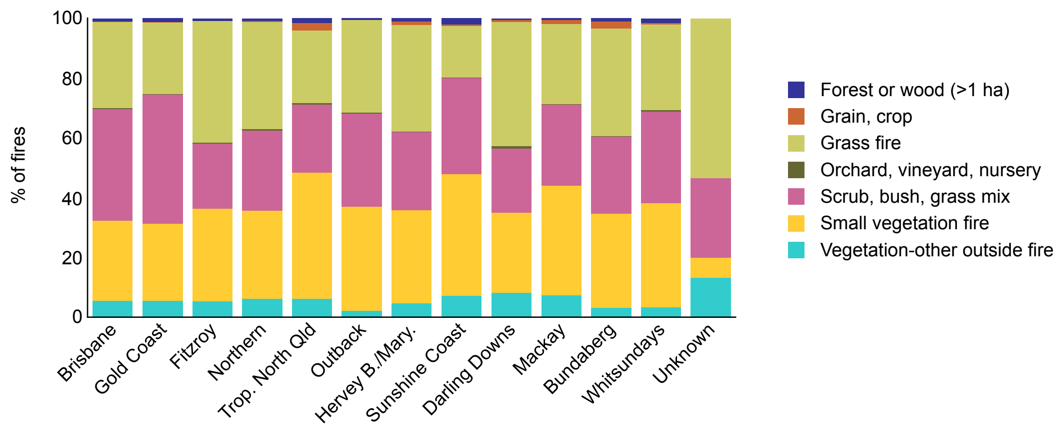
Source: QFRS 1997–98 to 2001–02 [computer file]

Figure 47: Type of incident, by cause



Source: QFRS 1997–98 to 2001–02 [computer file]

Figure 48: Region, by type of incident



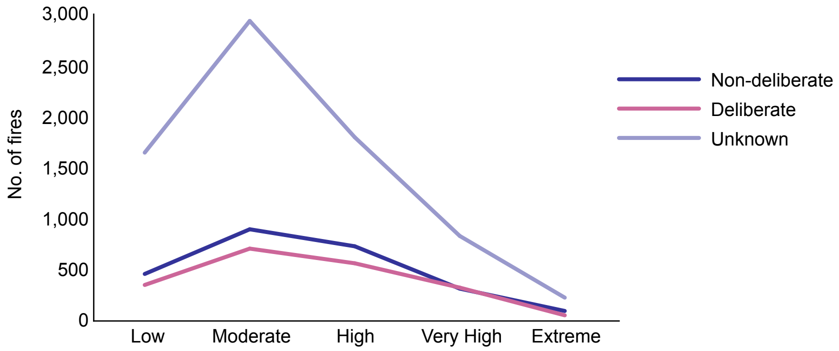
Source: QFRS 1997–98 to 2001–02 [computer file]

Bushfire danger

The fire danger rating was available for approximately one-quarter of fires the QFRS attended, although the small proportion of cases where causal attribution was known limits interpretation. The available evidence suggests that most fires occurred under moderate fire danger conditions. This was followed by high and low bushfire danger days, and subsequently by very high bushfire danger conditions (Figure 49). A very small proportion of fires occurred on extreme bushfire danger days.

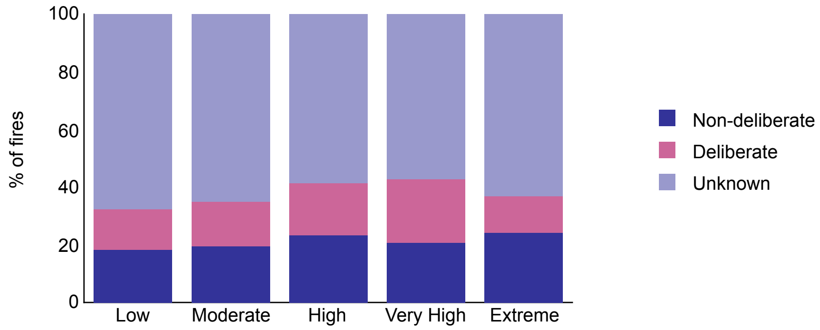
Although the ratio of deliberate to non-deliberate fires increased from low to very high bushfire danger conditions, this ratio was considerably lower for extreme bushfire weather (Figure 50). Considerable uncertainty exists within these results owing to the low number of vegetation fires for which both causal attributions were made and information pertaining to the bushfire danger period was available.

Figure 49: Bushfire danger, by cause



Source: QFRS 1997–98 to 2001–02 [computer file]

Figure 50: Fire danger condition, by cause



Source: QFRS 1997–98 to 2001–02 [computer file]

Forestry Plantations Queensland analysis

Background about the FPQ dataset and its analysis

Important information about the FPQ dataset and the methodology employed to analyse it is outlined below:

- The fire data were sourced from FPQ.
- The database spans from 1975–76 to October 2004, and hence principally reflects the lands under management of the Queensland Department of Primary Industries (inclusive of the various name changes), prior to 1999, and of FPQ subsequent to 1999. In considering the FPQ analysis it is necessary to take into account the reduction in land tenure over the interval, particularly following the large tenure transfer after 1999, following implementation of the South East Queensland Regional Forests Agreement.
- The database does not use AIRS classification codes.
- Cause was defined using the cause variable supplied (in some cases categories were summarised).
- All fires where the cause was identified as ‘Intentional: Illegal attempts at hazard reduction burning’, ‘Intentional: Malicious incendiarism’, ‘Intentional: Mischief making’ or ‘Intentional: Torching abandoned/stolen vehicle’ were classified as incendiary.
- All fires where the cause provided was classified as ‘Intentional: Unknown but suspected’ were labelled suspicious.
- Deliberate causes refer to fires defined as incendiary and suspicious above.
- All natural vegetation fires were the result of lightning.
- No information was available about the number of vegetation fires that FPQ believed were started by smoking-related materials or by children.
- The ‘regions’ used in the FPQ are based on FPQ districts.
- The dataset included information about the area burned.
- Information was available about fire danger index and weather conditions at the time the fire occurred in approximately one-quarter of cases.

For more detail about these methodologies see the methodology chapter.

Overview

Fires the FPQ attended can be summarised as:

- FPQ records indicate, attendance at 3,531 fires from 1975–76 to 2003–04, representing an average of 122 fires per season (SD=66; excludes 2004–05 data). The actual frequency of vegetation fires attended in a year ranged from a low of 17 in 1983–84 to a high of 239 in 1977–78 (Figure 51).
- Of the five years with the highest recorded numbers of vegetation fires, four were associated with seasons during which there was an El Niño event. Nevertheless, high fire numbers also occurred in 1979–80, 1990–91, 2000–01 and 2001–02, years that were not concurrent with an El Niño event. Nor, were higher fire numbers evident for the 2002–03 season (El Niño event). The number of fires attended in the latter year was similar to low values observed throughout much of the 1990s (45 to 85 fires per season). The number of fires attended after 1999–2000 were likely impacted by the transfer of substantial amounts of lands so the number of fires attended in any one year, including 2002–03, cannot be compared with each other or with previous years.

- Fires ranged from small through to large. Given the FPQ's jurisdiction, it is reasonable to assume that the majority of fires occurred in or near a highly vegetated area. Hence, the fires within this database were either bushfires or had the potential to develop into a bushfire under more adverse circumstances.
- Twenty percent of fires attended from 1975–76 to October 2004 were classified incendiary with a further 16 percent being regarded suspicious.
- One-third of all FPQ fires occurred in the Beerburrum district.
- The 3,573 fires the FPQ attended between 1975–76 and October 2004 burned around 1,580,444 ha; 18 percent of this was burned by fires of deliberate (principally suspicious) origin.

Cause

Deliberate (incendiary and suspicious combined) lightings accounted for 36.2 percent of FPQ-attended fires between 1975–76 and 2003–04, with the proportions of identified incendiary cases (20%) slightly outweighing suspicious cases (16%; Figure 52). In contrast to the QFRS data, almost 12 percent of fires were natural, with a further 23 percent being the result of accidental causes. Unknown attributions account for 28 percent of fires attended. Hence, deliberate causes accounted for 50 percent of known causes.

The proportion of deliberate fires varied between years, ranging from 17 percent in 1981–82 to 70 percent in 1998–99 (Figure 53). The highest proportions of deliberate fires occurred during the seasons with lowest total number of fires. At the beginning of the 1990s rates of deliberate fires jumped from about 25 to roughly 50 percent per annum. There is some uncertainty over the actual percentage of deliberate fires during the mid to late 1970s owing to higher proportions of fires of unknown cause. However, the proportion of unknown causes has remained comparatively low since the early 1980s. The large increase in the proportion of deliberate fires in the early 1990s appears to reflect a genuine increase in the number of deliberate fires rather than simply changes in the proportions of other causes. The average number of deliberate fires lit per year for the 1981–82 to 1988–89 period was 24. The average number lit per year between 1989–90 and 2003–04 was 60.

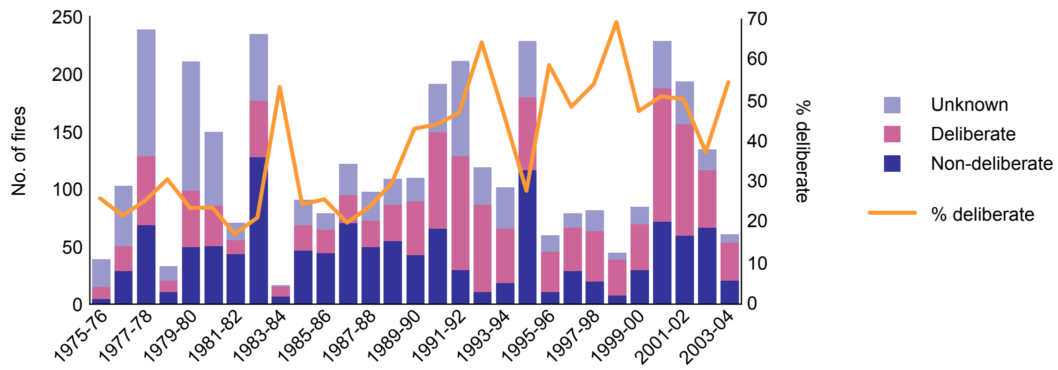
Specific ignition factors

The FPQ database incorporated ten separate causal categories, four relating to non-deliberate causes, one category to unknown causes, and five categories to deliberate causes (including unknown but suspicious fires). The most common human-related cause of non-deliberate fires occurred in instances where all reasonable care was taken (19.1%; Figure 54). Cases deemed to have been the result of carelessness (3.2%), gross negligence (0.5%) and reasonably foreseeable–stupidity (0.9%), appeared comparatively infrequently. Of the deliberate attributions, cases of suspected arson dominated (16.7% of all fires), followed by instances of malicious incendiarism (12.5%), the torching of abandoned/stolen vehicles (5.0%) and mischief making (1.4%).

Subtle temporal changes are evident in the number and proportions of some specific non-deliberate and deliberate causes, although caution is needed as the classification scheme of fire causes may have changed over the observation period. Of note is the decline in fires where all reasonable care was taken (Figure 55). This is counterbalanced by greater attributions of carelessness, gross negligence and stupidity. Collectively these trends may signify a lower tolerance by fire authorities toward avoidable bushfire ignitions rather than a significant shift in the attitudes of those lighting fires. A point particularly worthy of note is the marked reduction in the number (Figure 55) and proportion (Figure 56) of fires of unknown cause where arson was not suspected.

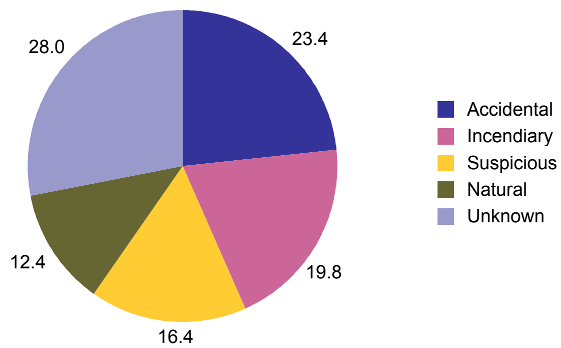
Although variable, the number (Figure 57) and proportion (Figure 58) of fires attributed to malicious incendiarism have tended to increase over the observation interval. The torching of abandoned/stolen vehicles increased markedly from the early 1990s onwards. In 2000–01, there were 24 reported cases of where vehicles were torched on or near FPQ lands. The proportions of 'unknown but suspicious' fires have fluctuated about a roughly uniform mean.

Figure 51: Cause of fires, by year



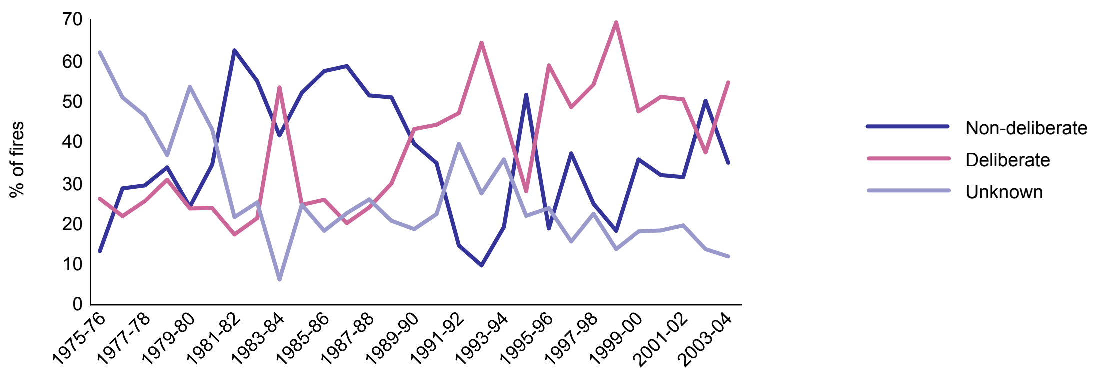
Source: FPQ 1975–76 to October 2004 [computer file]

Figure 52: Cause (percent)



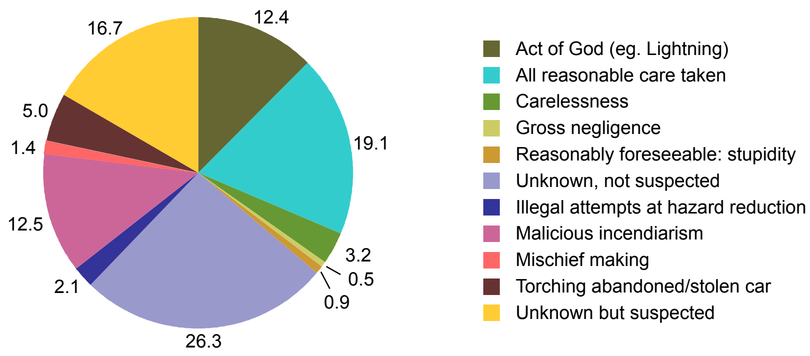
Source: FPQ 1975–76 to October 2004 [computer file]

Figure 53: Cause of fires, by year (percent)



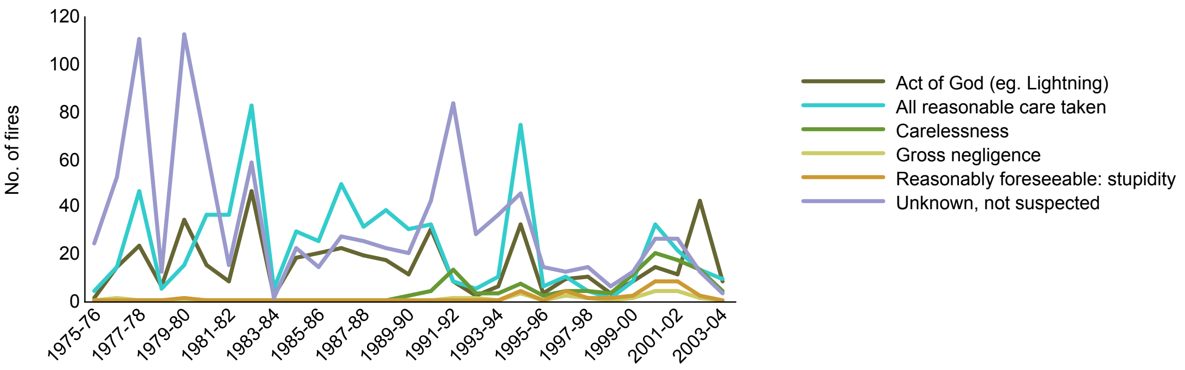
Source: FPQ 1975–76 to October 2004 [computer file]

Figure 54: FPQ cause (percent)



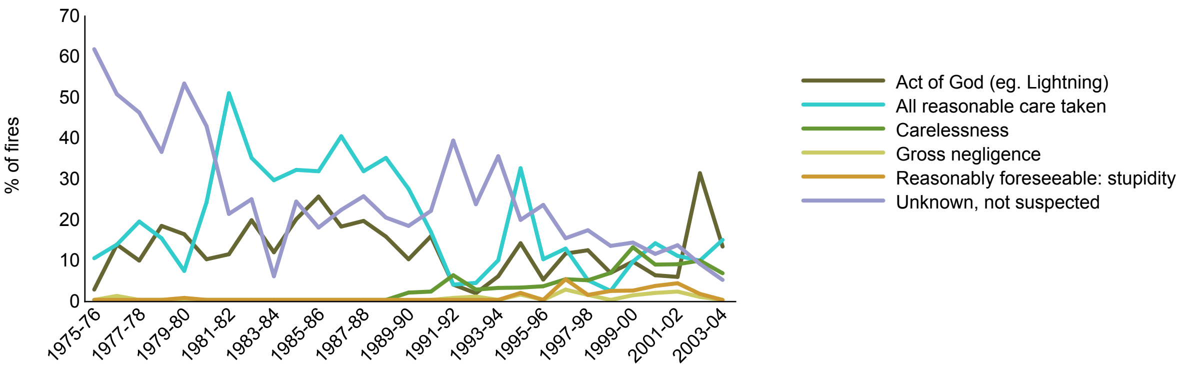
Source: FPQ 1975–76 to October 2004 [computer file]

Figure 55: Non-deliberate fires, by cause and year (number)



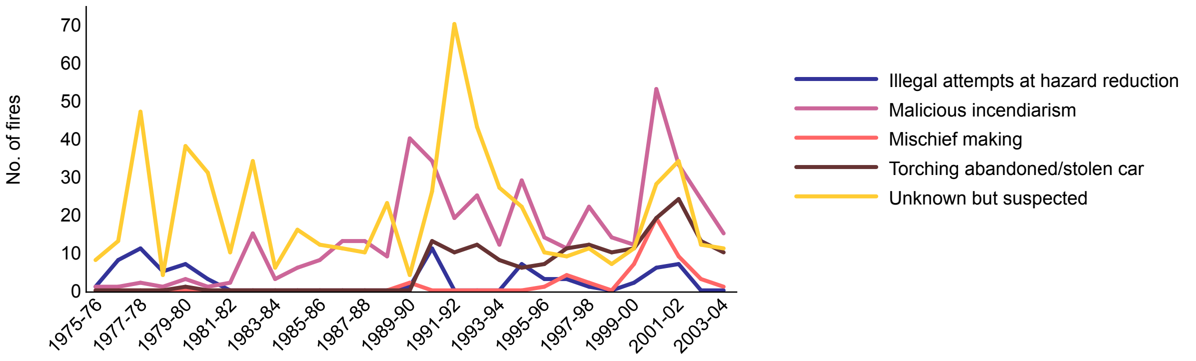
Source: FPQ 1975–76 to October 2004 [computer file]

Figure 56: Non-deliberate fires, by cause and year (percent)



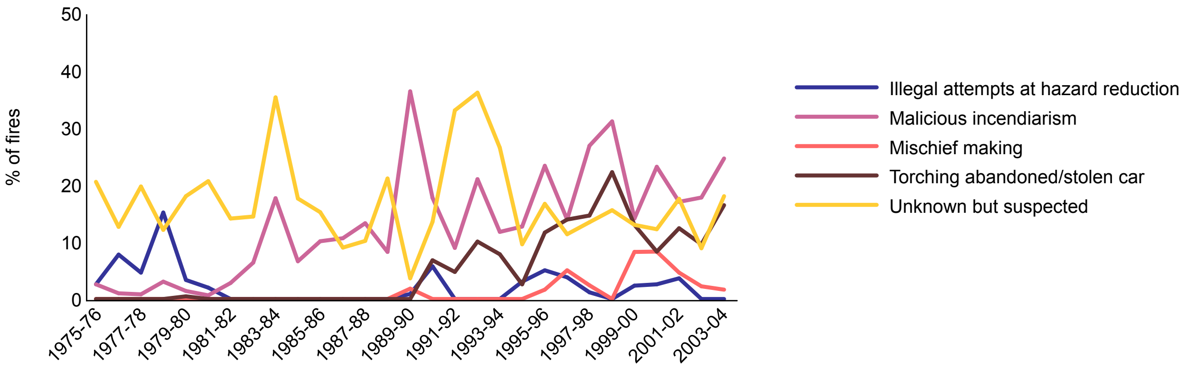
Source: FPQ 1975–76 to October 2004 [computer file]

Figure 57: Deliberate fires, by cause and year (number)



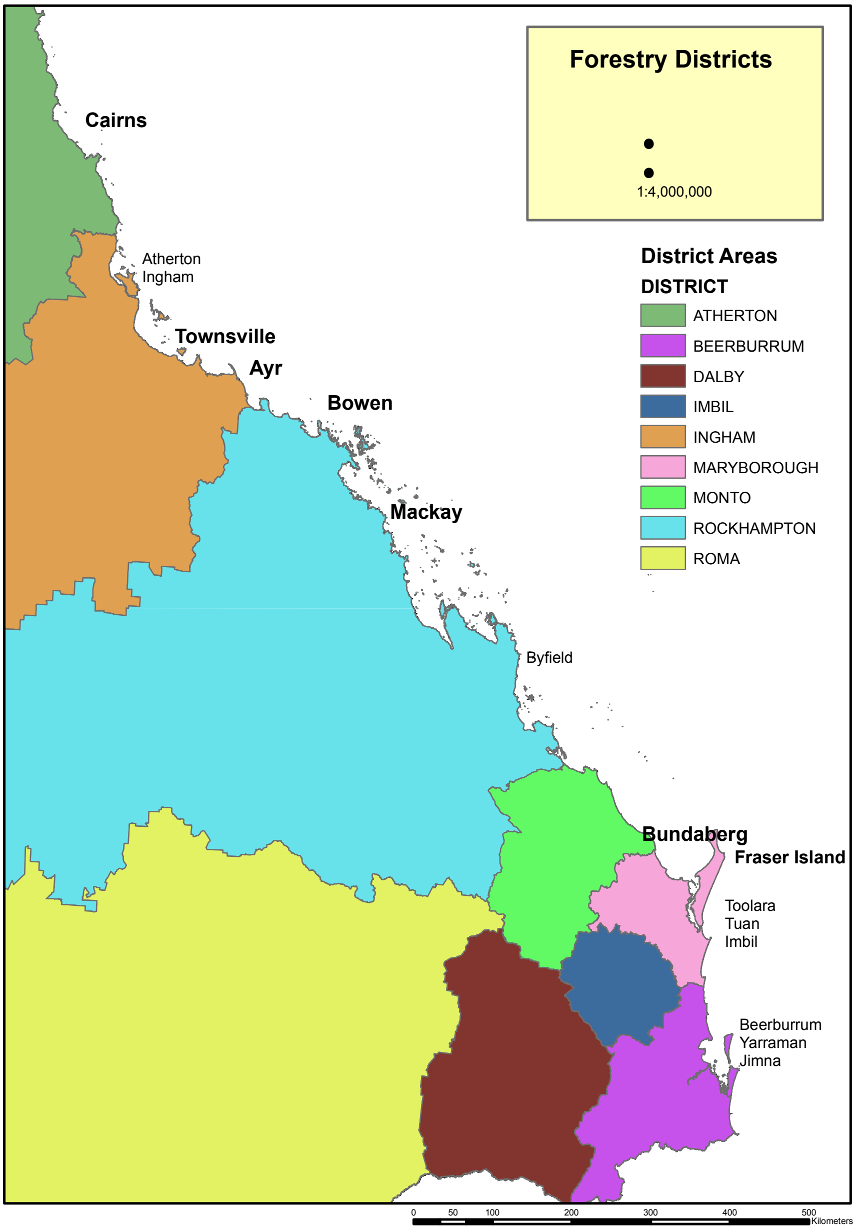
Source: FPQ 1975–76 to October 2004 [computer file]

Figure 58: Deliberate fires, by cause and year (percent)



Source: FPQ 1975–76 to October 2004 [computer file]

Figure 59: FPQ Forestry districts



Source: © Forestry Plantations Queensland

Location

Information about the location of fires is discussed in relation to the district and tenure where fires occurred.

District

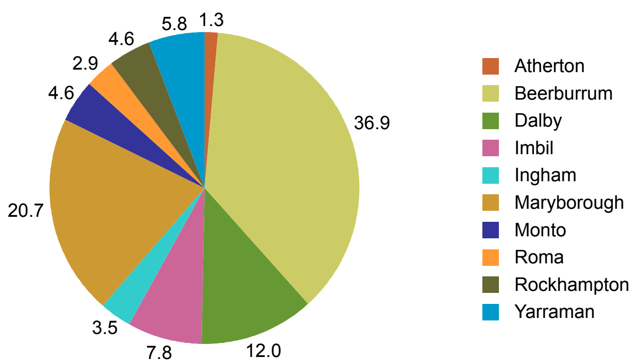
The distribution of fires within the FPQ database is necessarily influenced by the distribution of lands over which the FPQ had jurisdiction, and this has not remained uniform during the observation period. The distribution of lands used for forestry as at 1996–97 are illustrated in Figure 4.

FPQ define nine forestry districts (Figure 59). These differ from the regions used in the QFRS analysis. As a broad guide, Atherton lies in Tropical North Queensland, Ingham in the Northern District, Rockhampton in Fitzroy, Monto in the Bundaberg region, Roma in the Outback region, Dalby and Yarraman in the Darling Downs, Imbil and Maryborough in the Hervey Bay–Maryborough region, and Beerburrum in the Sunshine Coast region. The latter may however also include land within the Brisbane tourism region.

Thirty-seven percent of vegetation fires the FPQ attended occurred in the Beerburrum district (Figure 60), with the Maryborough, Dalby and Imbil districts accounting for a further 21, 12 and eight percent of fires the FPQ attended, respectively. The majority of fires occurred in the southeast of the state, within districts with both the highest density of FPQ forests and the areas of greatest population density and growth. Only about five percent of the FPQ fires occurred in the northern half of the state.

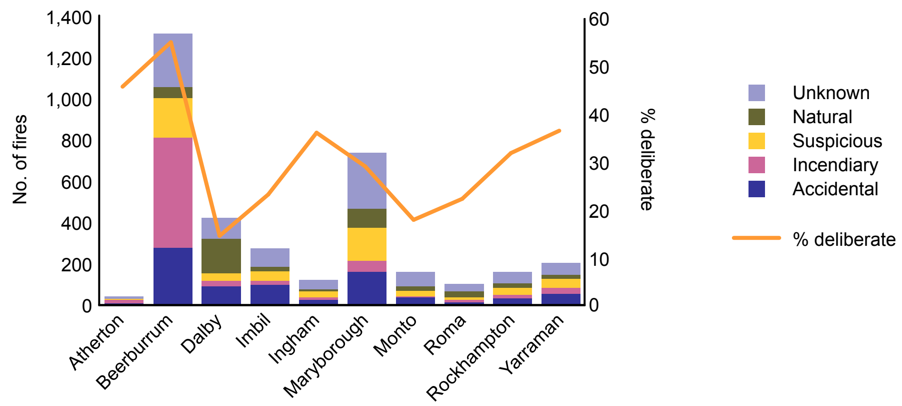
The greatest number and highest proportion of deliberate fires occurred in the Beerburrum district, with 55 percent of all fires in that area being deliberately lit (Figure 61). A high proportion of fires in the Atherton district were also deliberate but the incidence of such fires was very low (n=21). Natural fires were a major contributor to increased numbers of fires in the Dalby and to a lesser extent, Maryborough districts.

Figure 60: District (percent)



Source: FPQ 1975–76 to October 2004 [computer file]

Figure 61: Cause of fires, by district

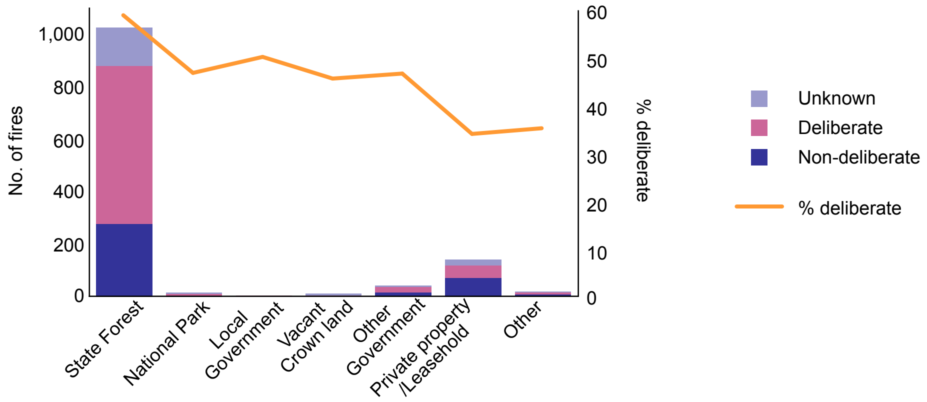


Source: FPQ 1975–76 to October 2004 [computer file]

Tenure

The tenure of property on which fires occurred was only identified in 35 percent of cases. Of these the majority (81%) were in state forests with a further 11 percent occurring on private property or leasehold; only one percent originated in national parks (Figure 62). The rates of deliberate fires were marginally higher in state forests than in other property types.

Figure 62: Tenure



Source: FPQ 1975–76 to October 2004 [computer file]

Timing

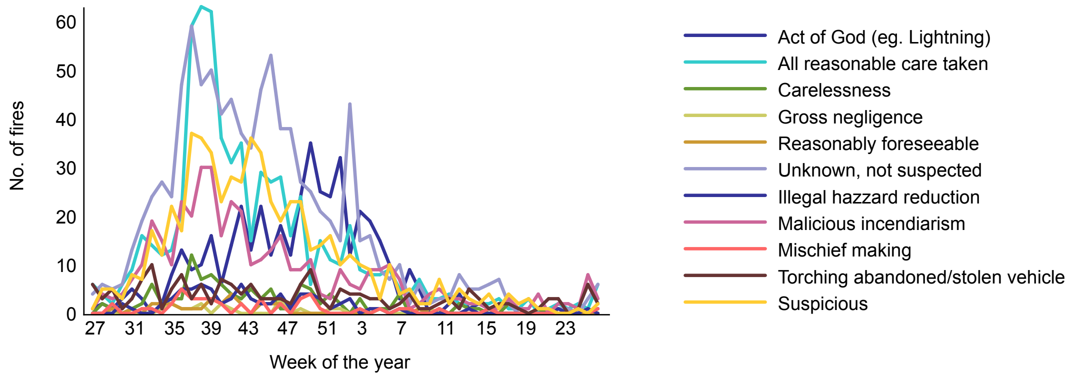
The timing of fires is examined by week of the year, day of the week and time of the day.

Week of the year

The number of fires the FPQ attended increased rapidly in late winter to early spring before decaying over the remainder of spring and summer. However, subtle differences were evident in the distributions for individual causes (Figure 63). Most human-caused fires occurred between mid August and mid January with the peak occurring in September. This was evident for both deliberate and non-deliberate causes. The peak in fires for which all reasonable care was taken (September) does not correspondent with the peak in natural fires (December). This may reflect the fact that many natural fires occurred in the Dalby district, where peak intensities in vegetation fires occurred somewhat later. Statewide, the number of natural fires increased from early October onwards, but also may vary from year to year.

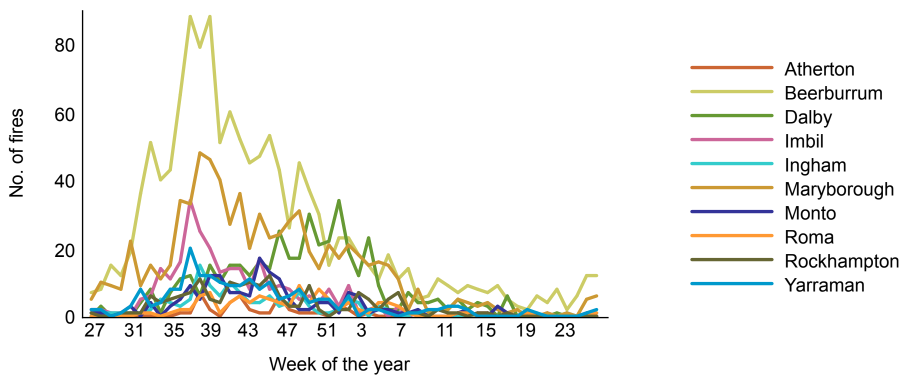
The timing and number of fires also varied markedly between years, but this is too complex to be able to illustrate figuratively. The timing of fires also varied subtly between regions (Figure 64). Most notable is that fires in the Dalby and, to a lesser extent, Roma districts tended to occur somewhat later than in other areas (Figure 65). In the Dalby area, the number of fires began to increase from early September onwards, peaking around early New Year. Fires in the Outback region and northern savannas tended to occur early in the calendar year than those in southern Queensland. Hence, the overall timing depends on the relative proportions of fires from regions with diverging fire regimes. Overall, comparatively few fires originated in either the Dalby or Atherton districts; hence the distribution of fires the FPQ attended most closely approximates the fire region that dominates in southeast Queensland.

Figure 63: Week of the year, by cause



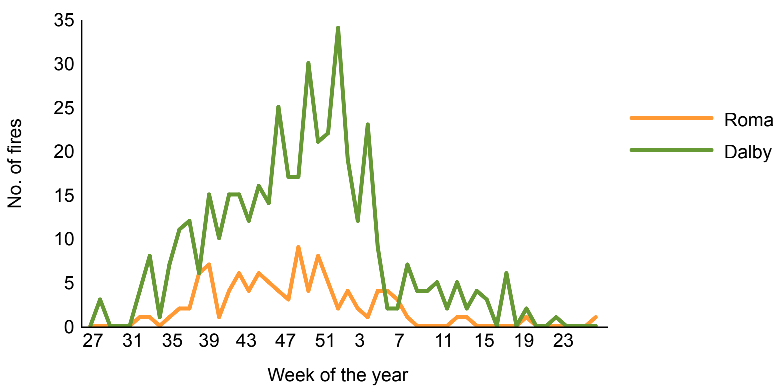
Source: FPQ 1975–76 to October 2004 [computer file]

Figure 64: Week of the year, by district



Source: FPQ 1975–76 to October 2004 [computer file]

Figure 65: Week of the year for Dalby and Roma districts



Source: FPQ 1975–76 to October 2004 [computer file]

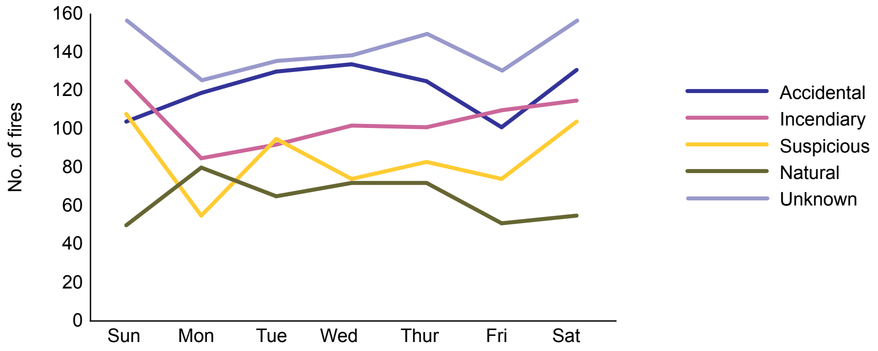
Day of the week

Overall, eight percent more fires occurred on Sunday and 12 percent on Saturdays than on the weekday average. However, this principally relates to the greater number of deliberate fires lit on those two days. Notably, 34 and 26 percent more deliberate fires occurred on Sunday and Saturday than on the average weekday. In contrast, non-deliberate fires were slightly less likely to happen on a weekend, or if they did occur on a weekend, were more likely to occur on a Saturday (Figure 66).

The increase in deliberate fires was observed across all categories, with the exception of mischief making. Seventeen to 20 percent more cases of malicious incendiarism occurred on Sunday and Saturday than on the weekday average. Approximately 40 percent more cases of torching of abandoned or stolen vehicle also occurred on Sunday and 24 percent more on Saturday than on the weekday average. A high number of illegal hazard reduction also occurred on Sunday.

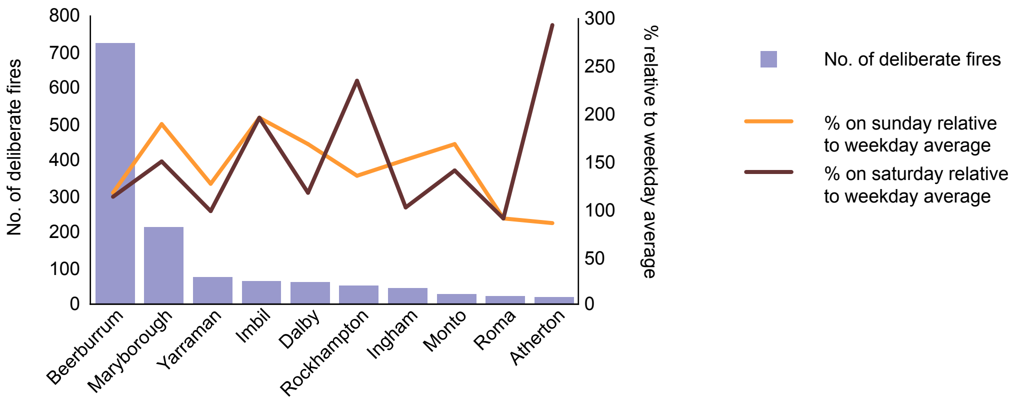
The extent of the increase in deliberate fire numbers on weekends varied between districts (Figure 67). In the Beerburrum district, an area characterised by a high number of deliberate vegetation fires generally, only 10 to 15 percent more deliberate fires occurred on Saturday and Sunday, whereas in Maryborough between 50 and 90 percent more deliberate fires occurred on weekend days. In Rockhampton, substantially more deliberate fires occurred on Saturdays than on Sundays, whereas in Maryborough, Ingham and Monto the reverse prevailed. In the Imbil district 90 percent more deliberate fires occurred on both Saturday and Sunday relative to the weekday average.

Figure 66: Day of the week, by cause



Source: FPQ 1975–76 to October 2004 [computer file]

Figure 67: Weekend bias, by forestry district



Source: FPQ 1975–76 to October 2004 [computer file]

Time of day

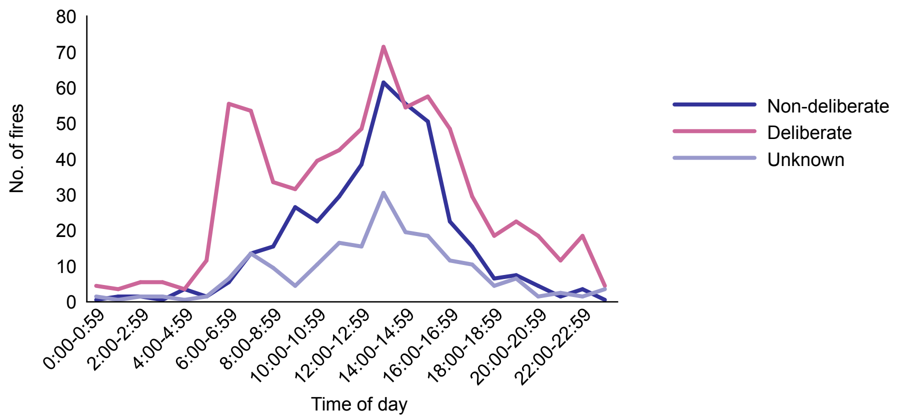
The overwhelming majority of FPQ-attended vegetation fires – be they deliberate or non-deliberate in origin – were detected during daylight hours. High numbers of non-deliberate fires occurred within a narrow window between 11 am and 4 pm (Figure 68). The peak was somewhat narrower and slightly earlier (1 to 2 pm) than the peak in non-deliberate fires documented for the QFRS data (3 to 4 pm). Unlike the QFRS data, the daytime peak for deliberate and non-deliberate fires coincided, with the 'midday' peak in deliberate fires being earlier than for QFRS-attended fires.

There was a high incidence of deliberate fires just after 6 pm. This trend was not evident for non-deliberate fires, but there were comparatively few fires detected between midnight and 5 am. However, the FPQ is characterised by a large spike in deliberate fires between 6 and 8 am. This spike is unique to the FPQ data, and although morning firesetting cannot be dismissed; it is more likely that this subset represents fires ignited the previous night but only detected the following morning.

Fires with detection times of between 6 and 8 am were primarily located in the Beerburrum area (compare Figure 69 and Figure 70). Of those fires in the Beerburrum area occurring between 6 and 8 am, 53 percent resulted from the torching of abandoned vehicles with a further 35 percent resulting from malicious incendiarism. Another 10 percent were suspicious in origin. Fires lit within this timeframe accounted for 11 percent of all malicious lightings and 31 percent of all torched vehicles the FPQ attended in the Beerburrum area.

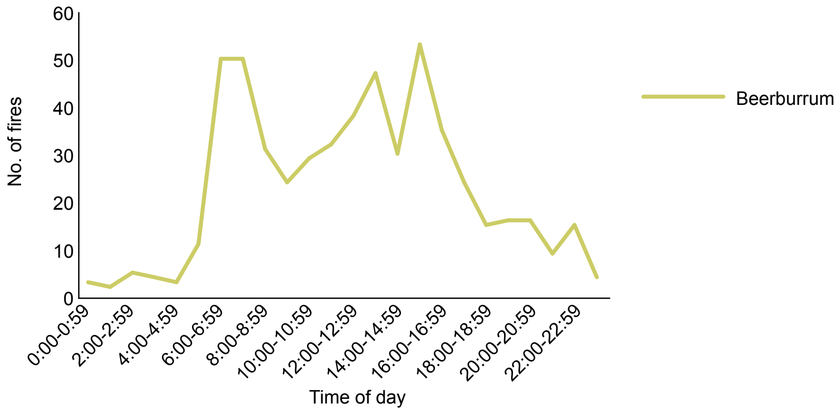
Cultural and social patterns, and hence temporal patterns of deliberate fires, are likely to have altered significantly in 29 years; patterns that were relevant in the late 1970s are unlikely to be the same as today. However, as the number of deliberate fires has increased over time, the general patterns described above were dominated by recent trends.

Figure 68: Detection time, by cause



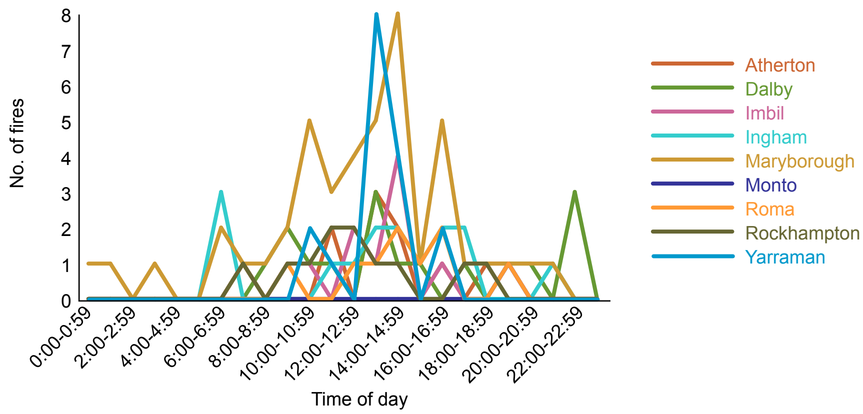
Source: FPQ 1975–76 to October 2004 [computer file]

Figure 69: Detection time of deliberate fires in the Beerburrum district



Source: FPQ 1975–76 to October 2004 [computer file]

Figure 70: Detection time of deliberate fires in selected districts



Source: FPQ 1975–76 to October 2004 [computer file]

Area burned

There was a sharp decrease in the number of vegetation fires with increasing fires size (Figure 71). Although similar to the trend observed for the QFRS data, there were clearly a higher proportion of moderate sized fires than in urban areas, with the pronounced spikes for the 10 to 49.9 and 100 to 499 ha categories. The latter were as frequent as fires within the less than one hectare category. An increased proportion of moderate-sized fires occurred across all causal categories, although subtly different distribution occurred for individual causes.

The majority of larger FPQ fires (those exceeding 1,000 ha) fires were natural, accidental (where reasonable care was taken) in origin, or the result of unknown causes (Figure 72). Natural fires accounted for all fires greater than 50,000 ha.

Deliberate fires accounted for a decreasing proportion of vegetation fires as the size of the fire (area burned) increased (Figure 72). This principally reflects decreases in the proportion of fires resulting from malicious incendiarism and the torching of abandoned and stolen vehicles. Fires of suspicious origin were more evenly distributed across area categories of varying size.

There were 341 deliberately lit fires that burned greater than 50 ha, 60 that burned greater than 1,000 ha, and five that burned greater than 10,000 ha. The largest occurred in the Monto district, covering an area of 25,000 ha. Nevertheless, some caution is needed when interpreting these results as the cause of 47 of the 60 fires that burned 1,000 ha or more was listed as 'unknown but suspected'. Six of the 60 fires that burned greater than 1,000 ha were identified as resulting from malicious incendiarism. The largest of these burned 10,600 ha in the Rockhampton area. A further six of the deliberately fires greater than 1,000 ha resulted from illegal attempts at hazard reduction. The largest of these occurred in the Roma district and burned 11,250 ha. That fires lit carelessly in natural reserves have the potential to cause significant damage is evidenced by the fact that one fire in the Beerburrum district that resulted from the torching of an abandoned or stolen vehicle subsequently burned 1,993 ha of land.

Between 1975–76 and October 2004, 1,580,444 ha were burned by the 3,573 fires that the FPQ attended; 45 percent of which was burned by non-deliberate fires. Approximately 17 percent of the total area burned resulted from lightning strikes (Figure 73) and accidental fires, where all reasonable care was taken, burned a further 25 percent of land.

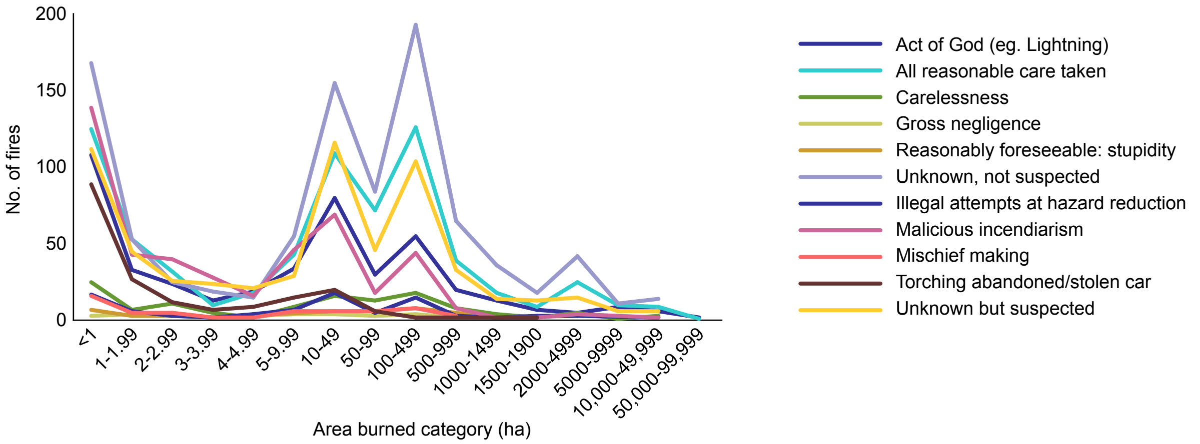
Deliberate or suspected fires were responsible for burning 18 percent of the total area burned. The majority of this relates to suspicious fires, with malicious incendiarism and the torching of vehicles accounting for just 2.5 and 0.2 percent of the total area burned, respectively (Figure 73).

The total area burned varied substantially across seasons, from a maximum of 229,570 ha during the drought of 1982–83 to a minimum of 2,580 ha in 1998–99 (Figure 74). Two of the three years during which very large areas were burned were associated with El Niño events, namely 1982–83 and 1994–95. The amount of land burned on FPQ lands during subsequent El Niño events (1997–98 and 2002–03) were not remarkable in comparison to the average yearly area burned. Prior transfers of land tenure may have affected total area burned in 2002–03.

Deliberate fires typically accounted for about 20 percent of the total area burned in one year, although in detail it was somewhat variable (Figure 74). Deliberate causes typically contributed to the highest proportions of area burned in years during which the total area burned was very low. Although the number of deliberate fires has increased, five-year averages reveal that the total area burned by deliberate fires has decreased since the peak in the late 1970s–early 1980s (Figure 75). This related to fundamental long-term changes in the size and distribution of FPQ-attended vegetation fires over time. The proportion of smaller fires, particularly those less than 10 ha, has increased substantially over the observation period (Figure 76). This may reflect improved response and firefighting capacity; or it may reflect a change in the character of fire setting, with an increasing propensity for a greater number of small deliberate fires – the class of fire that characterises many urban environments.

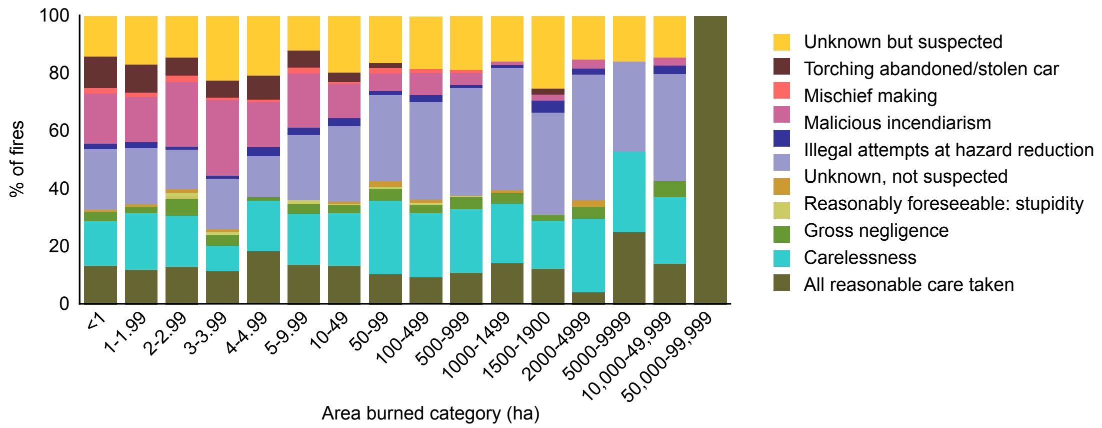
Between 1975–76 and October 2004 the greatest total area was burned in the Rockhampton, followed by Maryborough, Monto, Roma and Beerburrum districts (Figure 77). Comparatively smaller areas of land were burned in the Atherton, Ingham and Yarraman districts. Deliberate fires accounted for 20 percent of the total area across most districts (Figure 77). The notable exceptions were for the Atherton and Ingham districts, where the number of fires and the area burned by fires of all causes was very low. The size distribution of vegetation fires varied substantially between districts. Beerburrum accounted for a decreasing proportion of fires as fire-size increased (Figure 78). In contrast, Monto, Rockhampton and Roma accounted for a higher proportion of the total area burned as the total area burned increased.

Figure 71: Area burned category, by cause (number)



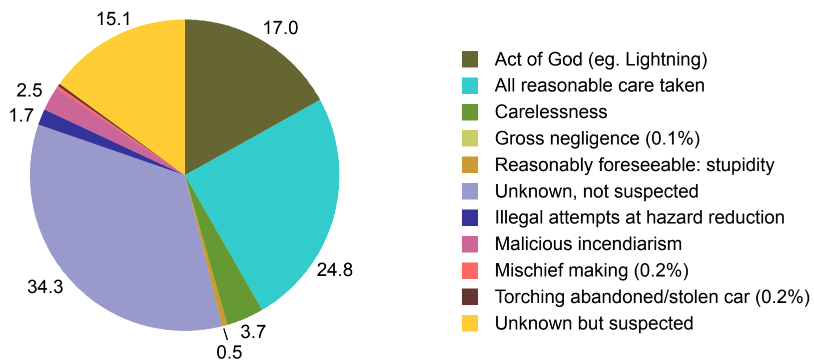
Source: FPQ 1975–76 to October 2004 [computer file]

Figure 72: Area burned category, by cause (percent)



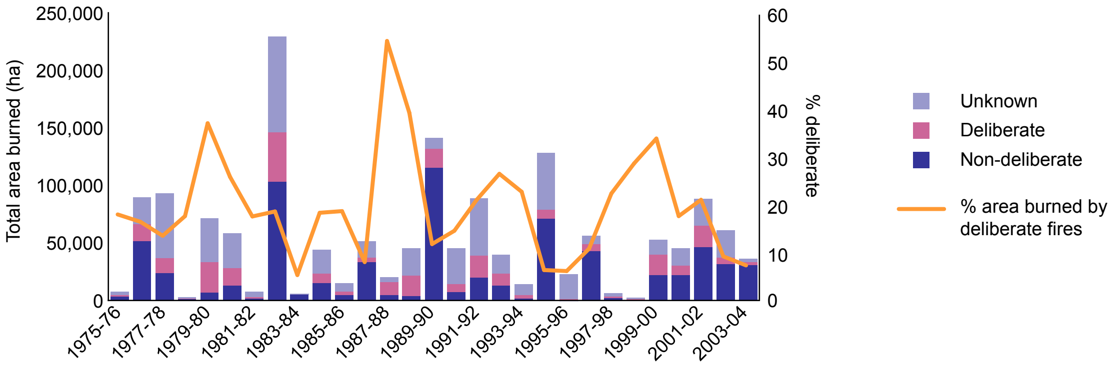
Source: FPQ 1975–76 to October 2004 [computer file]

Figure 73: Total area burned (percent)



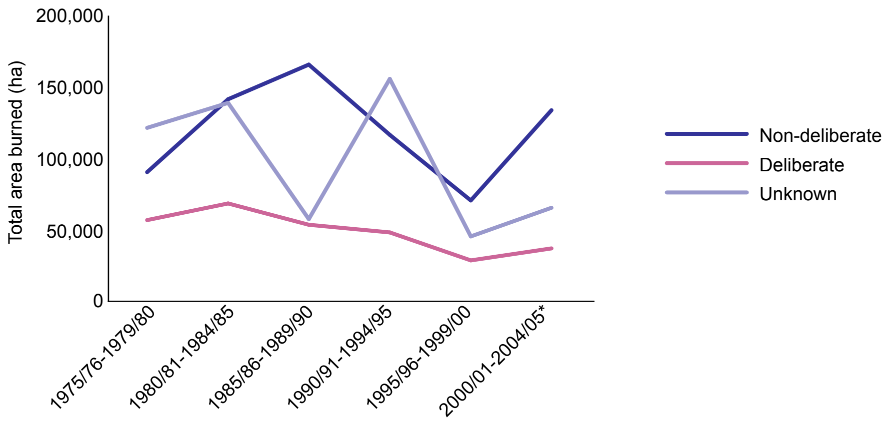
Source: FPQ 1975–76 to October 2004 [computer file]

Figure 74: Area burned, by cause each year



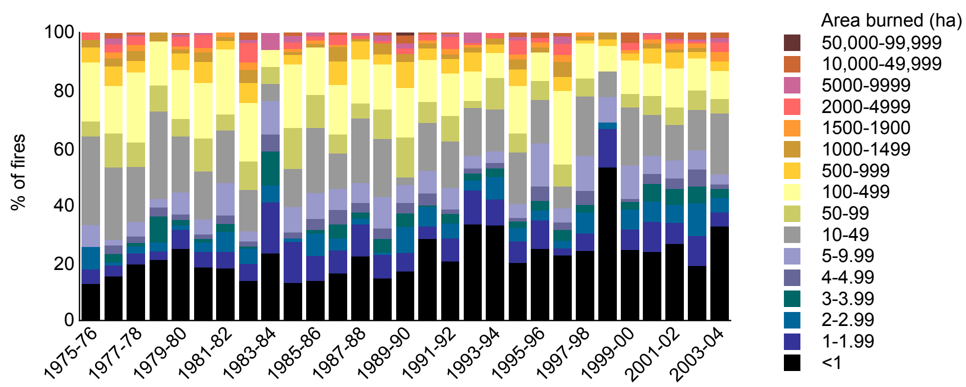
Source: FPQ 1975–76 to October 2004 [computer file]

Figure 75: Area burned, by cause in five-year intervals



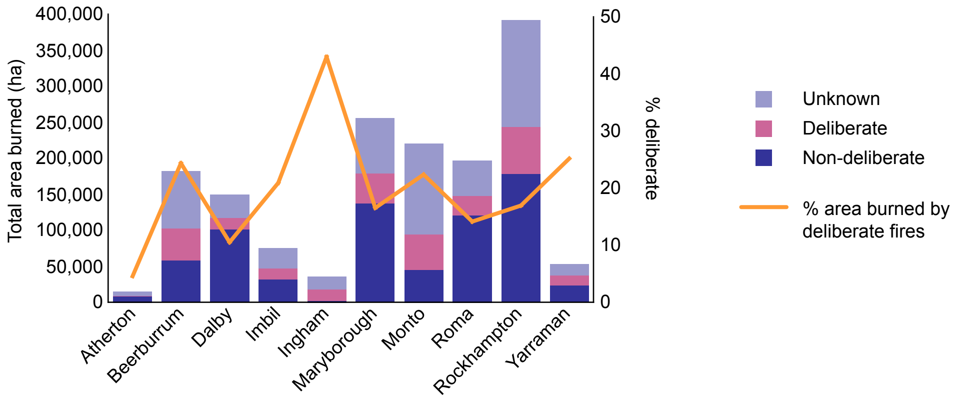
Source: FPQ 1975–76 to October 2004 [computer file]

Figure 76: Temporal changes in the size distribution of fires



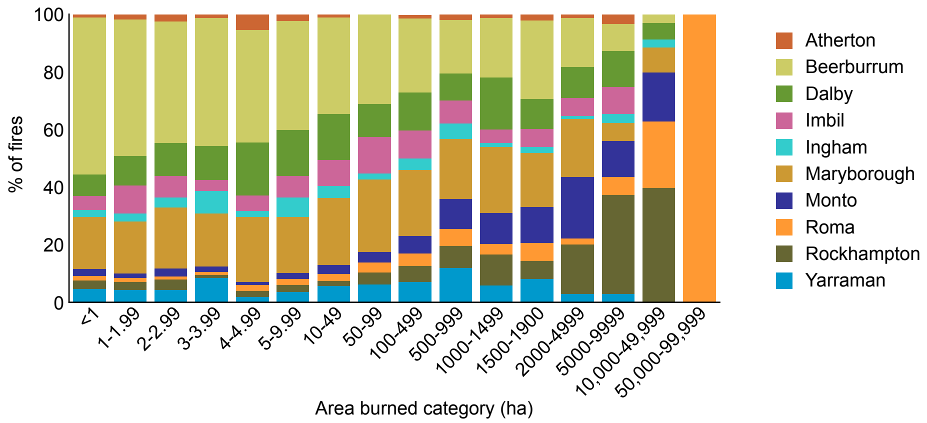
Source: FPQ 1975–76 to October 2004 [computer file]

Figure 77: Total area burned, by cause in each region



Source: FPQ 1975–76 to October 2004 [computer file]

Figure 78: Area burned category, by region (percent)



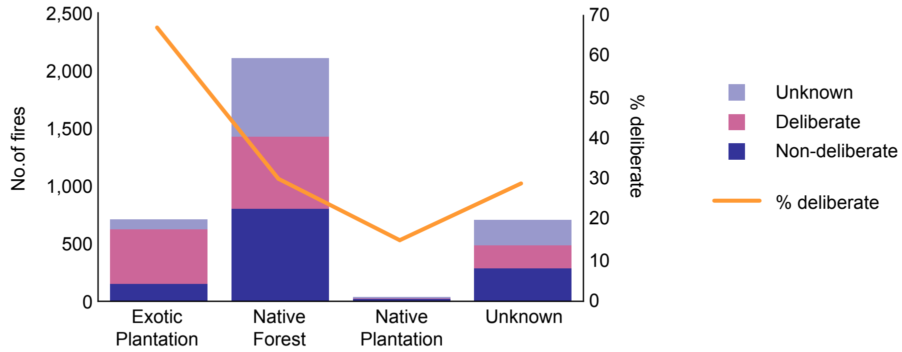
Source: FPQ 1975–76 to October 2004 [computer file]

Vegetation

Approximately 60 percent of fires the FPQ attended occurred in native forests with a further 20 percent in exotic plantations. Only one percent of fires occurred in native plantations. In 20 percent of cases the vegetation burned was unknown.

Approximately, 65 percent of fires in exotic plantations were, or were suspected of being, deliberately lit (Figure 79). At least 30 percent of fires in native forests were deliberately lit, although the actual figure was likely to have been much higher given the low level of causal attributions for this forest type.

Figure 79: Forest type, by cause



Source: FPQ 1975–76 to October 2004 [computer file]

Bushfire danger and weather

This section analyses the weather conditions, including temperature, humidity, wind speed and bushfire danger rating, at the time the fires occurred. This enables some assessment of the conditions under which people deliberately light fires.

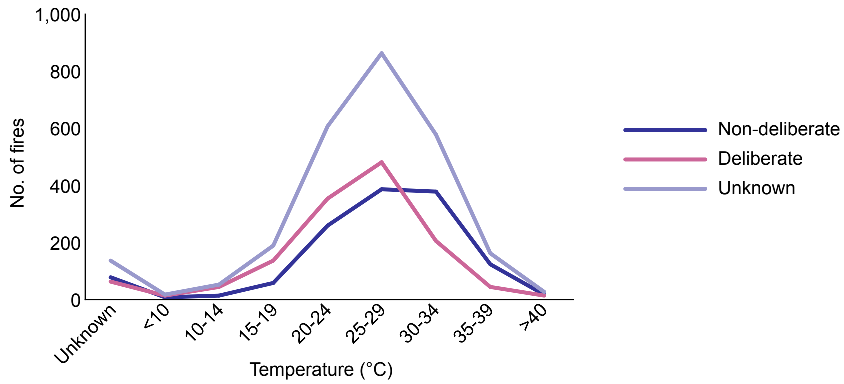
Temperature: Temperature data was available for 93.5 percent of fires the FPQ attended between 1975–76 and October 2004. Although the greatest number of both deliberate and non-deliberate fires occurred in the 25 to 29°C range it is evident from Figure 80, that non-deliberate fires were more likely to occur at higher temperatures than deliberate fires.

The distribution for non-deliberate fires is strongly influenced by natural fires, which peaked at temperatures of 30 to 34°C (Figure 81). Malicious incendiarism and the torching of abandoned or stolen vehicles tended to peak at lower temperatures than human-caused non-deliberate fires. However, this discrepancy is not evident for suspicious (unknown but suspected) fires, illegal attempts at hazard reduction, or fires resulting from mischief making. The numbers of deliberate fires that occurred when the temperatures exceeded 40°C was very small (Figure 80); only two fires occurring at temperatures exceeding 40°C were attributed to malicious incendiarism, but a further seven were suspicious in origin. However, only one of those suspected cases occurred after June 1994.

The extent to which the listed temperature corresponds to the temperature at the precise time the fire started is unclear. The data were reanalysed to only include those fires that were detected between 10 am and 6 pm, thereby excluding the spike in deliberate fires between 6 and 8 am. If the temperature recordings are accurate, then the inclusion of the latter fires – fires that were more likely to have been lit at night – would generate comparatively lower average temperatures for deliberate compared with non-deliberate fires. The 10 am to 6 pm interval is also of interest as it represents the interval where fires were more likely to spread and therefore pose the greatest danger.

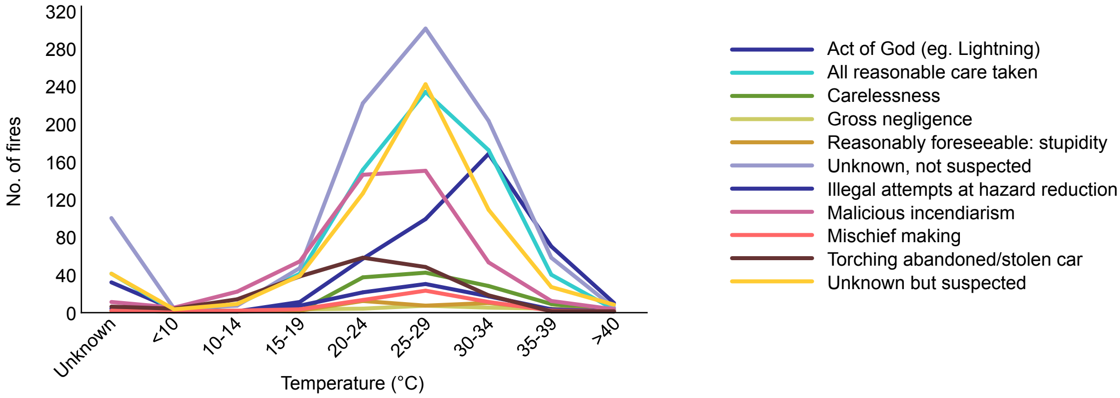
A total of 795 fires occurred between 10 am and 6 pm for which both time and temperature were known (98 percent of those cases where time was known). It is clear that the trends for deliberate and non-deliberate fires are more alike when data pertaining to fires lit between 6 pm and 10 am are removed. Notably, there were fewer deliberate fires within the less than 15°C and, to a lesser extent, the 15 to 19°C categories. The ratio of deliberate to non-deliberate fires at higher temperatures is largely unchanged (Figure 82). These results imply that the temperatures were largely indicative of the time that fire occurred, and that the strong bias toward lower temperature for deliberate fires was affected by the greater number of night-time–early morning fires when compared with non-deliberate causes. Nevertheless, it remains that malicious incendiarism, torching of motor vehicles and, to a lesser extent, suspicious fires occurred at marginally lower temperatures than accidental causes for fires between 10 am and 6 pm (Figure 83).

Figure 80: Temperate, by cause



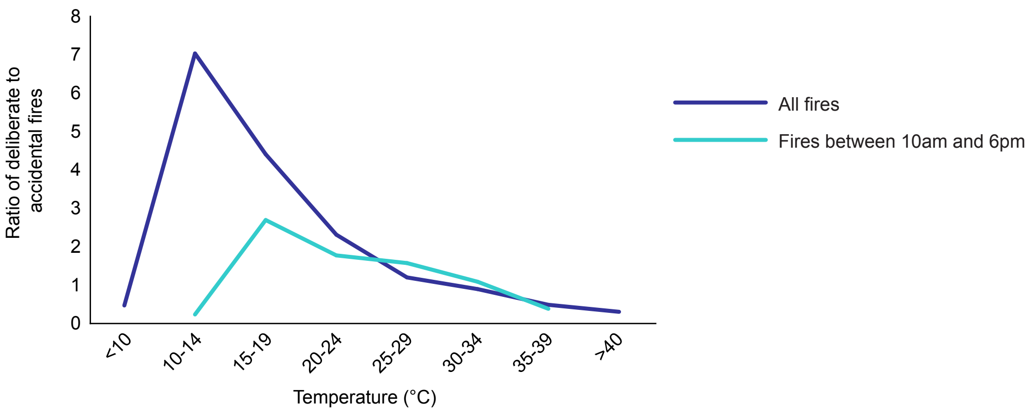
Source: FPQ 1975–76 to October 2004 [computer file]

Figure 81: Temperate, by specific cause



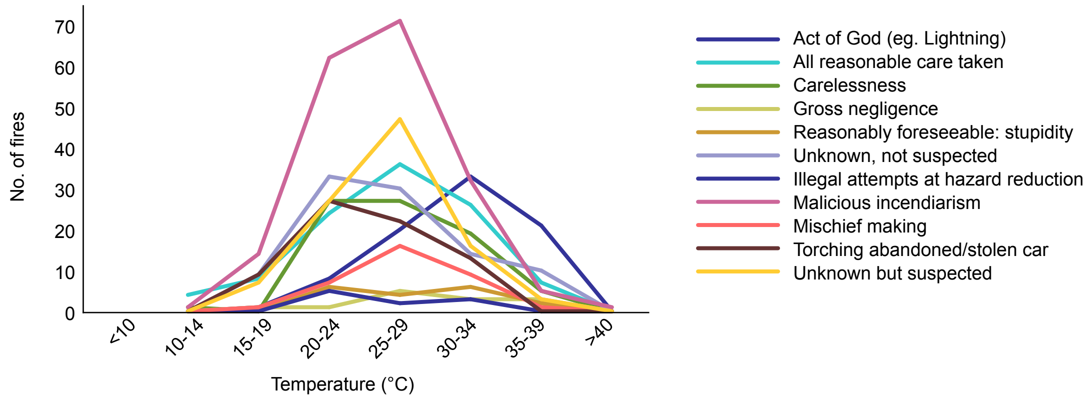
Source: FPQ 1975–76 to October 2004 [computer file]

Figure 82: Deliberate/non-deliberate ratio, by temperature



Source: FPQ 1975–76 to October 2004 [computer file]

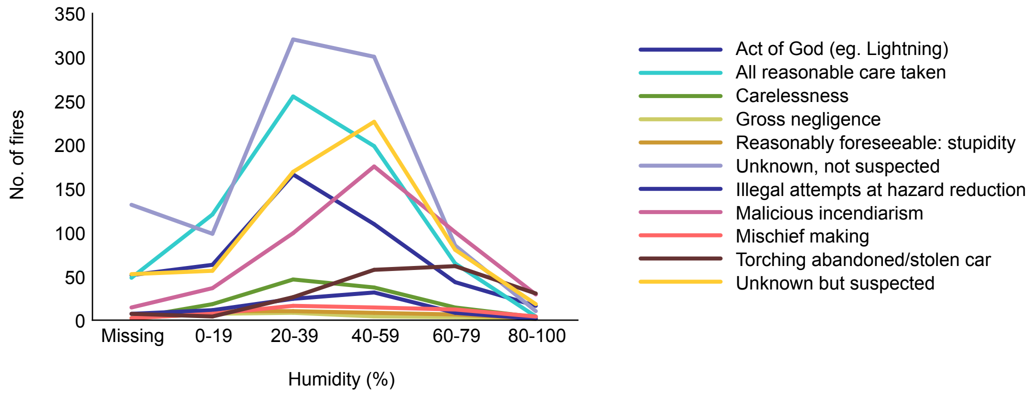
Figure 83: Temperature, by specific cause for fires occurring between 10 am and 6 pm based on cause



Source: FPQ 1975–76 to October 2004 [computer file]

Humidity: Variations in the humidity for deliberate and non-deliberate fires mirror that observed for temperature. Natural fires were more likely to occur on low humidity days, whereas malicious incendiarism and vehicle torching occurred under comparatively more humid conditions (Figure 84).

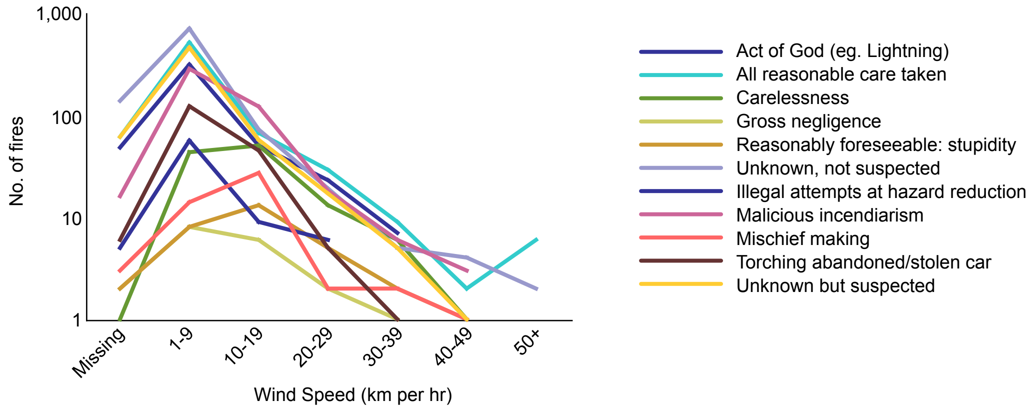
Figure 84: Humidity, by cause



Source: FPQ 1975–76 to October 2004 [computer file]

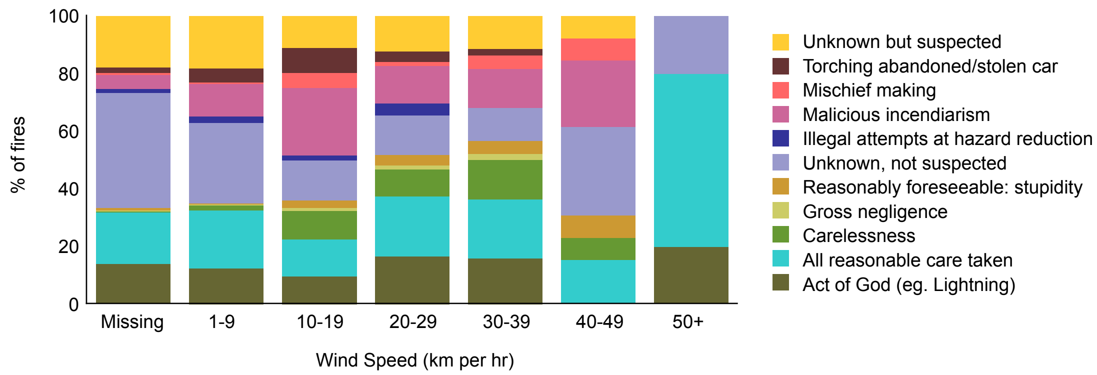
Wind speed: The vast majority of all FPQ-attended vegetation fires, irrespective of cause, occurred on days where wind speed was less than 10 km per hour, with the frequency of fires decreasing as wind speed increased (Figure 85). Nevertheless, for causes such as ‘carelessness’, ‘reasonably foreseeable–stupidity’, and ‘mischief making’, where the total frequencies were low, the maximum occurred in the 10 to 19 km per hour category. Malicious incendiarism also accounted for a disproportionate number of fires within the 10 to 19 km per hour range (Figure 86). However, most fires started under conditions where the wind speed exceeded 50 km per hour were the result of lightning strikes or were attributed to accidental causes where all reasonable care was taken. No illegal attempts at hazard reduction occurred on days where the wind speed exceeded 30 km per hour.

Figure 85: Wind speed, by cause (number)



Source: FPQ 1975–76 to October 2004 [computer file]

Figure 86: Wind speed, by cause (percent)



Source: FPQ 1975–76 to October 2004 [computer file]

Bushfire danger: The bushfire danger rating takes in account the weather (temperature, humidity and wind speed) as well as factors such as the levels of curing within vegetation.

Most deliberately lit fires occurred on low bushfire danger days; with fewer deliberate fires occurring as the bushfire danger increased (Figure 87). Seventy percent of deliberately lit fires occurred during a low or moderate bushfire danger ratings, with only 5.4 and 0.5 percent occurring during very high and extreme bushfire danger periods. In contrast, the number of non-deliberate fires peaked on moderate bushfire danger days, followed by high and then low bushfire danger rating days, respectively. Only a small proportion of all fires, deliberate and non-deliberate, occurred under conditions of extreme bushfire weather (Figure 87), but a lower proportion of deliberate fires occurred under high to extreme bushfire conditions than non-deliberate fires (Figure 88).

The proportion of deliberate and non-deliberate fires that occurred during a high to extreme bushfire danger period varied between districts, a reflection of the varying climatic conditions across the state, as well as differences in land use patterns and population distributions. The climatic conditions place a natural limitation on the number of days and hence the probability for ignition under each bushfire danger rating. For example, no deliberately lit fires (Figure 89), and only five percent of non-deliberate fires (Figure 90) in the Atherton district occurred during periods of high to extreme fire danger. In contrast, in Dalby, which is located further inland and has a drier climate, 54 percent of fires occurred during high to extreme bushfire danger ratings; eight percent of deliberate fires and 36 percent of non-deliberate fires occurred under conditions of high to extreme fire danger. In the Imbil district, 49 percent of fires occurred on high to extreme fire days. Again, these were primarily non-deliberate in origin. Only eight percent of deliberate lightings and approximately eight percent of non-deliberate fires in the Beerburrum district occurred during high to extreme bushfire danger periods. Of these the majority were under conditions of high and to a less extent very high, rather than extreme danger ratings. The only area where deliberate fires exceeded non-deliberate fires under high to extreme bushfire danger conditions occurred in the Ingham district, but as this is based on a sample of four it is not significant. The highest percentage of fires of unknown cause during high to extreme bushfire danger periods occurred in the Imbil, Monto, Dalby and Yarraman districts.

The proportion of non-deliberate fires that occurred during high to extreme bushfire danger days was systematically correlated with the total proportion of fires that occurred during high to extreme bushfire conditions in each district ($r=.96$, $p<.001$), with non-deliberate causes being the principle cause of fire under high to extreme fire danger conditions (Figure 91). However, the actual incidence of fires during high to extreme bushfire danger periods was intimately related to the total frequency of fires, and hence the population distribution across the state. Although the proportion of fires occurring during high to extreme fire danger periods in the Beerburrum district was low, this area recorded the greatest number of fires occurring under high to extreme bushfire danger as it has such a high number of fires.

This illustrates is the, perhaps fortunate, preference for the population in Queensland, and Australia in general, to inhabit coastal areas with their milder climatic conditions and less extreme bushfire conditions. It is evident from this discussion that, were population density to increase in areas that experience more severe weather conditions, the number of deliberate fires during high to extreme bushfire danger periods would become increasing problematic. By combining population density structures and bushfire danger studies it should be possible to model total fire frequency and deliberate frequencies based on climate (that is, distribution of bushfire danger period within the fire season) and the regional distribution of the population with respect to climatic zones. This could be of immense benefit to land planning and the necessary provision of services that may be needed to cater for likely bushfire outcomes, in the absence of more intensive effort to prevent bushfire arson.

Not surprisingly, there was an intimate relationship between the size distribution of vegetation fires and the inherent bushfire danger conditions, with large fires accounting for an ever-increasing proportion of fires as bushfire conditions worsened (Figure 92). These changes were evident for both non-deliberate (Figure 93) and deliberate fires (Figure 94). As the bushfire danger increased from low to very high there was:

- a decrease in the relative size of the less than one hectare spike
- a subtle decrease in the proportion of fires in the three to 10 ha category
- very little change in the proportion of fires in the 10 to 50 ha category as the bushfire danger increases from low to very high
- a substantial increase in the proportion of fires in 100 to 500 ha category.

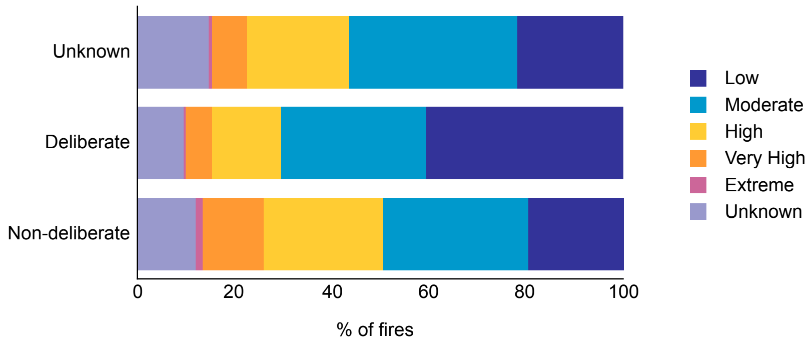
With a shift from very high to extreme bushfire danger weather there was a marked shift to larger fire sizes. In addition to significantly lower frequencies in the less than one ha category, there was a virtual absence of fires between two–three ha and 50 ha. Although the spike at 100 to 500 ha remained, there was a large increase in the proportion of fires within the 500 to 1,000 ha category, and a greater proportion of even larger fires occurred. In effect, there is a shift in the entire frequency distribution to the right in Figure 93 and Figure 94, toward greater fire sizes. Approximately 60 percent of fires that occurred on extreme fire danger days burned greater than 100 ha. Almost 20 percent burned more than 1,000 ha.

The perceived risk associated with the rapid spread of bushfires under extreme conditions appears to be manifest in the FPQ records. However, comparatively few fires the FPQ attended occurred under conditions of extreme bushfire weather and, despite the larger fire sizes, the total area burned under such conditions was less than that burned under mild conditions (Figure 95). This reflects the interplay between frequency and severity. As discussed, fire frequency is largely a function of human actions and is related to population distributions, whereas the bushfire danger is largely governed by the climate–weather in a particular area. These two variables are not independent, as climate plays a significant part in the population distribution across the state. In most coastal areas, there were a large number of small fires, and the greatest total area was burned under low to moderate bushfire danger conditions. By contrast, in the drier areas further inland (such as Dalby) the greatest total areas were burned under moderate and high bushfire danger conditions (Figure 96).

Figure 87: Bushfire danger rating, by cause (number)

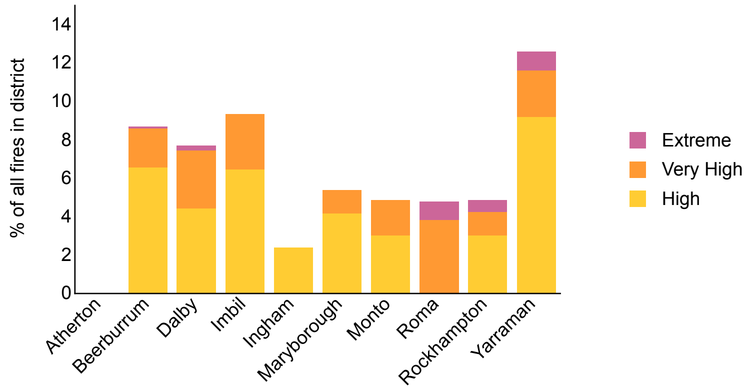
Source: FPQ 1975–76 to October 2004 [computer file]

Figure 88: Cause, by bushfire danger rating (percent)



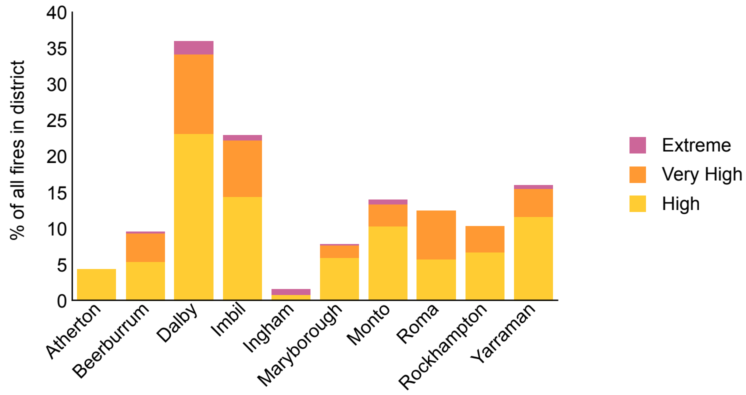
Source: FPQ 1975–76 to October 2004 [computer file]

Figure 89: Deliberate fires under high to extreme bushfire danger conditions, by region (percent)



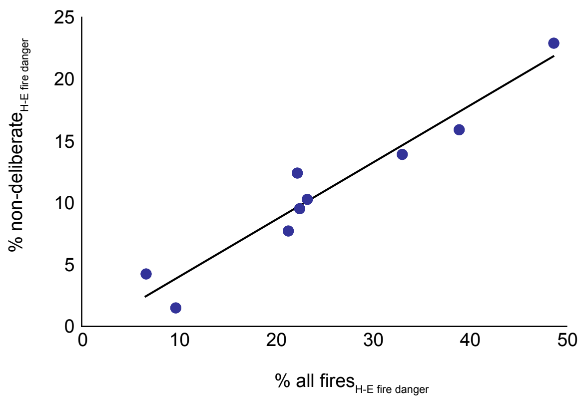
Source: FPQ 1975–76 to October 2004 [computer file]

Figure 90: Non-deliberate fires under high to extreme bushfire danger conditions, by region (percent)



Source: FPQ 1975–76 to October 2004 [computer file]

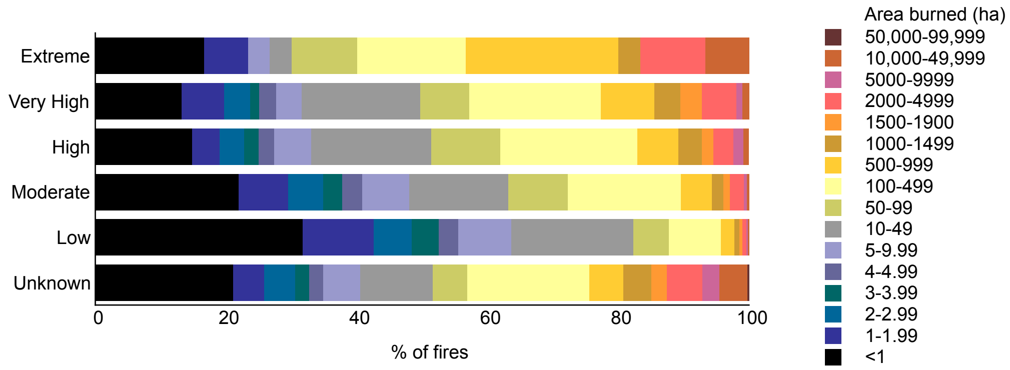
Figure 91: Fires occurring under high to extreme bushfire conditions[a]



a: % all fires H-E fire danger = the percentage of all fires in each district that occurred under high to extreme bushfire danger conditions; % non-deliberateH-E fire danger = the percentage of all fires in each district that occurred under high to extreme bushfire danger conditions and that were non-deliberate in origin; that is, % all fires H-E fire danger = % non-deliberate H-E fire danger + % deliberate H-E fire danger + % unknown H-E fire danger

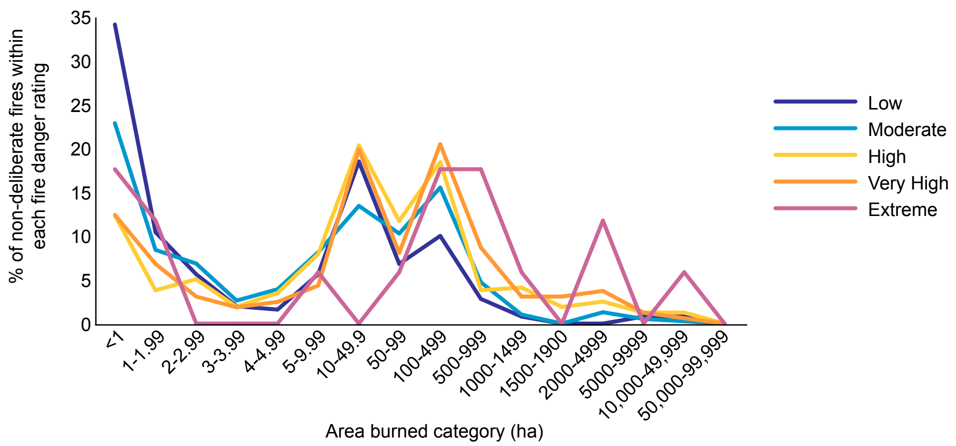
Source: FPQ 1975–76 to October 2004 [computer file]

Figure 92: Bushfire danger, by area burned category (percent)



Source: FPQ 1975–76 to October 2004 [computer file]

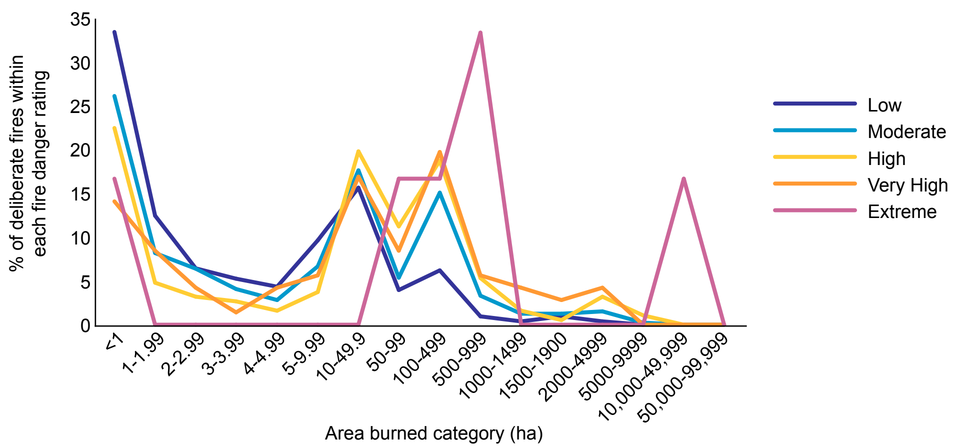
Figure 93: Bushfire danger (percent)[a], by area burned (percent) for non-deliberate fires



Note: a Represents the percentage of all fires with each fire danger rating that occurred within specific area burned categories

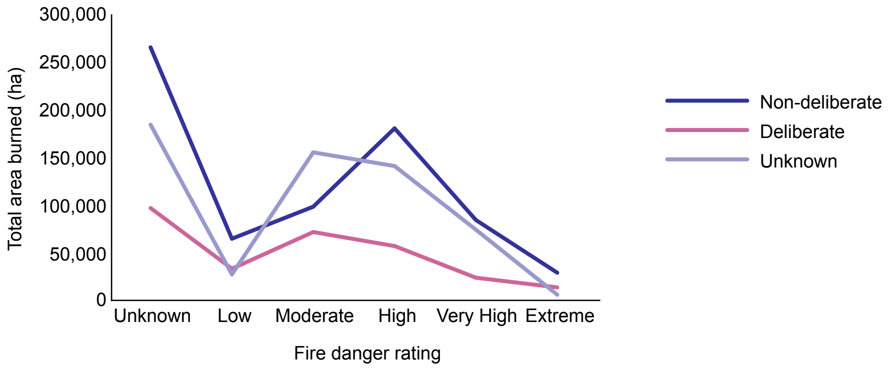
Source: FPQ 1975–76 to October 2004 [computer file]

Figure 94: Bushfire danger (percent)[a], by area burned (percent) for deliberate fires



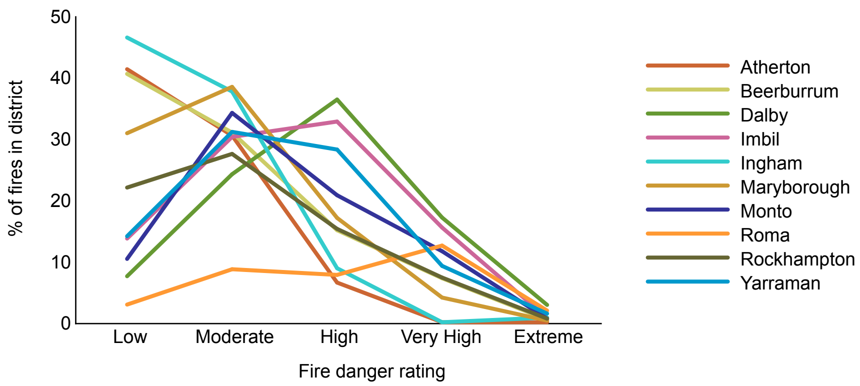
Source: FPQ 1975–76 to October 2004 [computer file]

Figure 95: Total area burned, by cause under varying bushfire danger conditions



Source: FPQ 1975–76 to October 2004 [computer file]

Figure 96: Bushfire danger, by region (percent)



Source: FPQ 1975–76 to October 2004 [computer file]

BEERBURRUM: A CASE STUDY

A high proportion of all FPQ-attended vegetation fires occurred in the Beerburrum district and a high proportion of those fires were deliberately lit. This case study examines the nature of bushfire activity in the Beerburrum district.

The yearly fluctuations in the number of fires in the Beerburrum district parallels the overall trend observed for FPQ data, highlighting the extent to which fire patterns in this district influenced state-wide trends observed in the FPQ data (Figure 51 and Figure 97). The proportion of FPQ fires occurring in the Beerburrum district increased from 20 to 25 percent in the early 1980s to almost 70 percent in 1998–99 (Figure 97), although this has subsequently decreased to between 45 or 50 percent. Commensurately, the proportion of deliberately lit fires in the Beerburrum district increased from approximately 30 percent in the early 1980s up to 60 to 80 percent since the early 1990s (Figure 98), with a distinct jump in both frequency and proportion of deliberate fires occurring in 1989–90. The increase primarily reflects the increased frequency of fires classified as malicious incendiarism and to a lesser extent the torching of stolen or abandoned cars (Figure 99). Attempts at illegal hazard reduction have remained relative constant over the same interval although three spikes of activity were evident in the late 1970s, the early 1990s, and early 2000s.

Interpretations of long-term changes are hampered by uncertainty posed by higher proportions of unknown causes during the early portion of the observation period. Notably, there have been greater levels of causal attributions since the late 1970s, which can lead to apparent increases in the rates of deliberate fires. However, the proportion of unknown and deliberate fires combined (that is, the maximum possible rate for deliberate fires) increased from 50 to 60 percent in the mid 1980s to 80 to 90 percent since the mid 1990s. Although it is not impossible that the rate of deliberate fires has remained relatively constant over the 29-year period it is more probable that both the frequency and proportion of deliberate lightings have increased.

This increase in deliberate fires in the Beerburrum area coincided with a phenomenal population growth in southeast Queensland during the same interval (Figure 100). Similar trends are also evident in the QFRS data in both the Brisbane and Gold Coast regions that have experienced massive population growth.

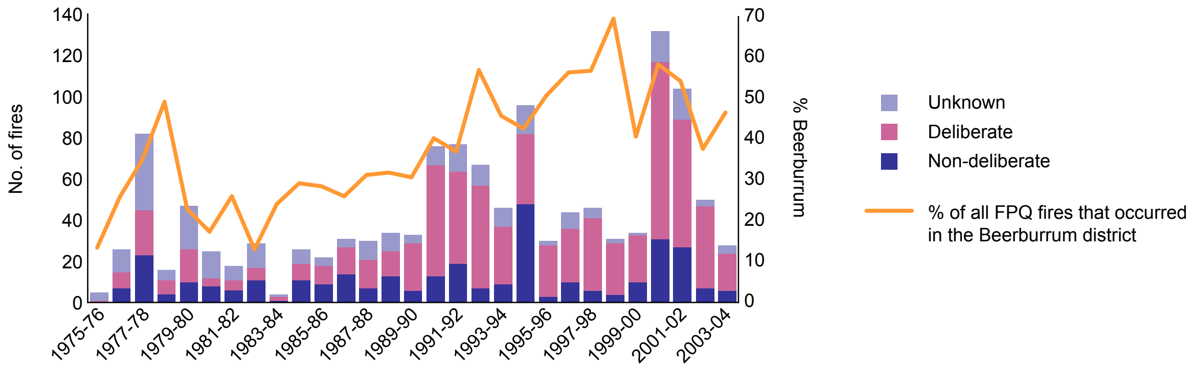
Although there is broad correlation between a higher population and greater fire frequency this relationship breaks down when examined in detail. Beerburrum lies within the Sunshine Coast tourism region (ABS 2005), which as a whole has experienced massive population growth. However, the incidence of bushfires on the Sunshine Coast (QFRS data) is substantially lower than in most other areas with an equivalent population. For example, the QFRS attended just 1,654 vegetation fires in 27 postcodes within the Sunshine Coast region in five years. During the same period, the QFRS attended 3,718 fires in 16 postcodes of the Northern region (combined population of 194,384) and 1,863 fires in 15 postcodes of the Hervey Bay–Maryborough region (combined population of 140,437). The apparent incongruence between the FPQ and QFRS data may relate to the heterogeneous demographics distribution in the Beerburrum–Sunshine Coast region.

Beerburrum is located midway between Caboolture (Brisbane region) and Caloundra (Sunshine Coast region). Although the population of the postcodes incorporating Caloundra and Caboolture are roughly similar (approximately 35,000 and 30,000 respectively), the prevalence of fires in these regions is remarkably different. QFRS data indicate 335 fires in the Caloundra postcode but 923 in the Caboolture postcode between 1997–98 and 2001–02. These differences are likely related to the substantially different population demographics evident for these two regions. Caloundra is characterised by a high proportion of the population aged over 45, with unusually high proportions of people older than 65 (ABS 2001d; Figure 101). In contrast, Caboolture has a younger demographic, with a higher frequency and proportion of the population that are younger than 25 years (ABS 2001c), an age group that is more commonly associated with greater numbers of fires (for example, Murphy, Nicolopoulos ,& Sandinata 1997). While it is beyond the capacity of this study to conduct a detailed analysis of the relationship between bushfires and how demographics may impact on distribution patterns of deliberate fires generally, this is an avenue of research that requires more attention.

A closer analysis of the Beerburrum data indicates that the number of deliberate fires tended to be concentrated within spatially restricted locations. The logging areas that experienced the highest frequency of fires included Toorbul (n=86), Twins (n=54), Bluegum (n=36) and Coochin (n=36; Figure 102). Higher frequencies in the Toorbul and Twins logging areas principally resulted from increased numbers of deliberate fires during the 2000–01 and to a lesser extent the 2001–02 seasons, consistent with serial firesetting by an individuals within these areas.

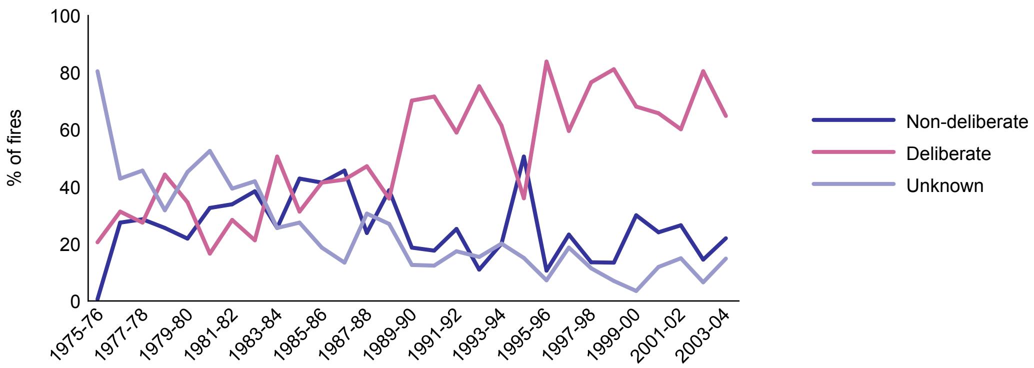
A high proportion of the fires in the Toorbul and Twins logging areas resulted from the torching of abandoned or stolen vehicles. In 2000–01 and 2001–02, 11 fires in the Twins logging area were identified as the result of malicious incendiarism, one from mischief-making, and eight from the torching of abandoned or stolen vehicles. During the same interval, 14 of the 30 fires in Toorbul resulted from malicious incendiarism, one from mischief-making, nine from the torching of stolen or abandoned vehicles, with a further five cases being regarded as suspicious. Approximately 50 percent of the fires that occurred in these two districts over the 29-year period related to the torching of vehicles. In the two years 2000–01 and 2001–02, 42 percent of fires the FPQ attended were attributed to malicious incendiarism and 40 percent of all fires involving the torching of abandoned or stolen vehicles occurred in the Toorbul and Twins regions. That a high number of malicious incendiary fires and theft and torching of motor vehicles occurred in the same area is not surprising if we consider that similar triggers give rise to a variety of antisocial behaviours; it is simply the means of expression that varies.

Figure 97: Fires by cause, each year, in the Beerburrum district (number)



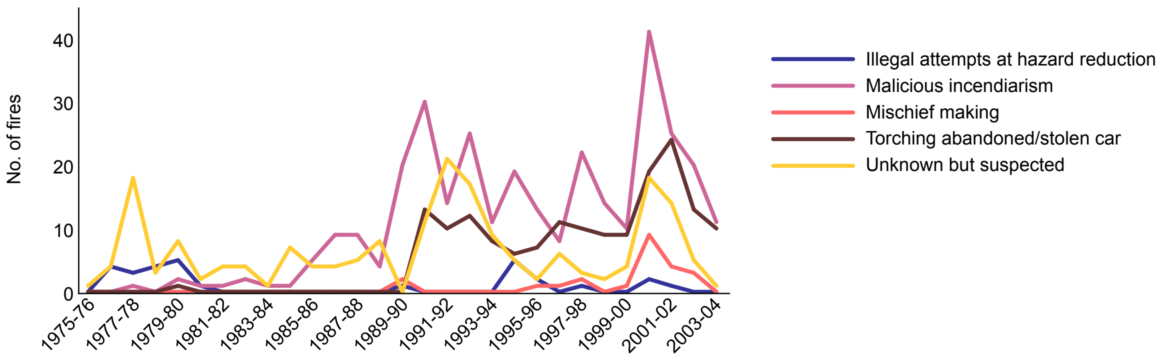
Source: FPQ 1975–76 to October 2004 [computer file]

Figure 98: Fires by cause, each year, in the Beerburrum district (percent)



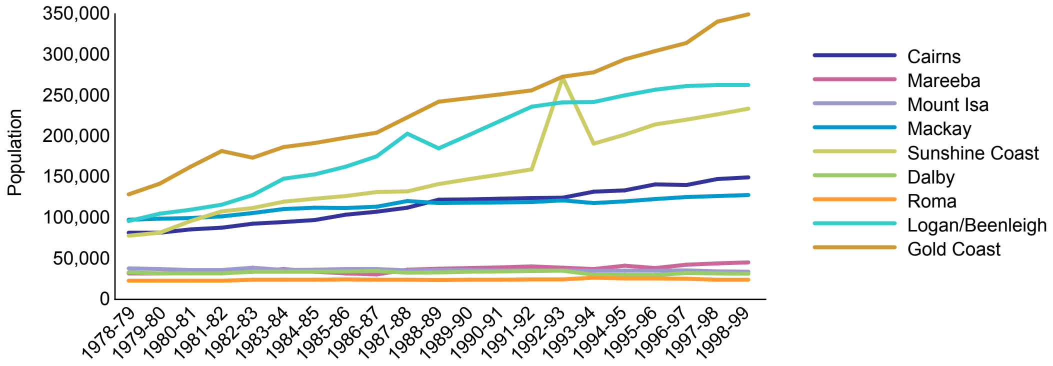
Source: FPQ 1975–76 to October 2004 [computer file]

Figure 99: Fires by cause, each year, in the Beerburrum district (number)



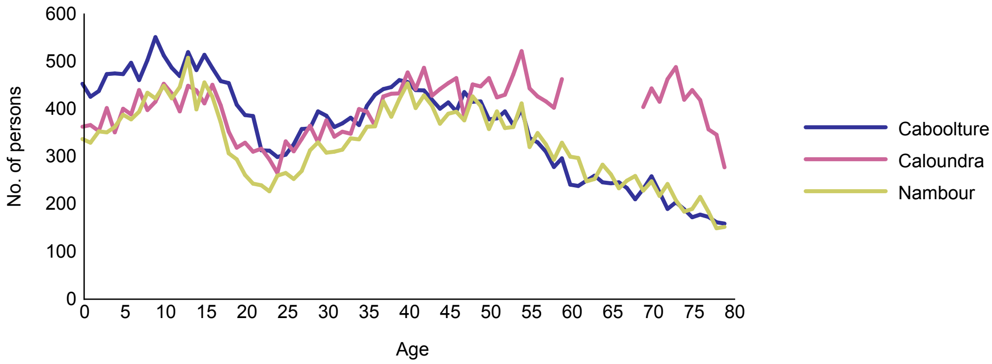
Source: FPQ 1975–76 to October 2004 [computer file]

Figure 100: Population for selected Queensland statistical regions, by year (number)



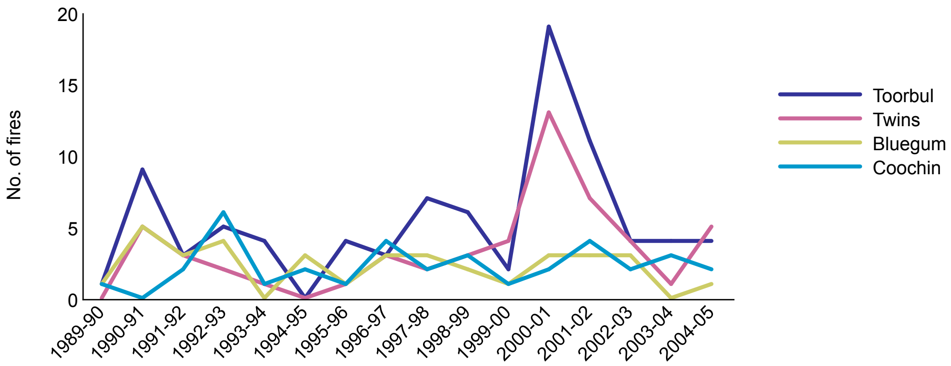
Source: Queensland Police Service 1978–79 to 1998–99

Figure 101: Population age in Caboolture, Caloundra and Nambour postal areas



Source: ABS 2001c,d,e

Figure 102: Deliberate fires in specific logging areas in the Beerburrum district



Source: FPQ 1975–76 to October 2004 [computer file]

Queensland Parks and Wildlife Service analysis

Background about the QPWS dataset and its analysis

Data from the QPWS was sourced from their current database structure, ParkInfo. Although this dataset included fires from as early as 1975–76 through to 2003–04, the dataset is incomplete. Entry of fire data into ParkInfo has been occurring retrospectively and a substantive amount of historic data has not yet been entered into the database. Moreover, ParkInfo was not rolled out across QPWS centres until 2003, consequently, pre 1993 data are likely to be incomplete. In addition, the focus of reporting fire incidents has changed markedly for the QPWS. Historically, little rigor was attributed to the causal category as the main focus was on the area burned, fire intensity and damage. In this light is it highlighted that, although the QPWS's capacity to report and record more accurate data continues to improve, both through ParkInfo and its web-based component, Fire Advice Web, there are unavoidable limitations to accuracy available for analysis.

In addition, it is reiterated that the lands under QPWS's jurisdiction have changed markedly during the observation period, from just one million hectares in 1975 to its current estate of nearly 12 million hectares. Transfers have been occurring since the 1975 separation of national parks from forestry including Cooloola, Fraser Island, Wet Tropics, South East Queensland Regional Forest Agreements and will continue with the Western Hardwoods Forest process. The merging of custodial forest management with parks management in 2001 provided the greatest integration of fire management responsibility. The complex arrangements surrounding tenure transfer have meant the area falling under the QPWS jurisdiction has grown markedly. Although attempts have been made to maintain contiguous fire records for individual reserves during those transfers, there are differences in interpretation for data fields even though a common system of reporting is in place. An additional implication of those transfers and complex fire management arrangements is that individual fire records may be duplicated across the various land management agencies. This may be above and beyond that normally experienced by agencies in the same jurisdiction, where two agencies attending the same fire individually record that information in their respective databases.

Given this, analysis of QPWS data has focused on vegetation fires from 1999–2000 to 2003–04, but it is stressed that information prior to 2003 is incomplete, that there is likely some duplication between the FPQ and QPWS databases, and that transfers between agencies have affected data quality. Therefore, any apparent 'trends' should be interpreted with caution; the figures cited in the text should provide a rough guide only, and not represent an absolute or completely accurate guide to the number, cause or temporal and spatial distribution of fires within current QPWS reserves.

Additional important points with respect to the methodologies adopted in the analysis are:

- The dataset provided only included wildfires (vegetation fires).
- The database does not use AIRS classification codes.
- The causal categories used in this analysis were defined using the cause variable provided.
- Deliberate vegetation fires include all vegetation fires classified as incendiary (fires classified as arson where the cause certainty variable was 'known') or suspicious (fires classified as arson where the cause certainty variable was listed as 'suspected').
- All natural fires were the result of lightning.
- No detailed information was available regarding smoking-related fires or fires attributed to children.
- The definition of regions used in the QPWS analysis is based on ABS (2005) tourism regions, being equivalent to that used for the QFRS analysis. The assignation of specific fire events to a tourism region was based on the reserve name. It is, however, highlighted that individual reserves may cross those boundaries, owing to the large extent of individual parcels of land.

- The dataset included information about the area burned, but no information was available about fire restrictions or fire danger index at the time fires occurred.
- Information was available about the tenure of land on which the fire occurred.

For more detail about these methodologies see the methodology chapter.

Overview

Fires the QPWS attended can be summarised as:

- ParkInfo records indicate attendance at 409 fires in the five years incorporating 1999–2000 to 2003–04. As noted, these records may be incomplete, with actual attendances being slightly higher. ParkInfo contained 128 unique fire records for 2002–03 and 126 for 2003–04 (Figure 103). These later years (at least partially in the case of 2002–03) are likely to provide the most accurate guide to QPWS fires as they incorporate fires that post-date ParkInfo's introduction.
- Given the nature of the QPWS, and the fire management responsibilities that lie within its jurisdiction, it is not unreasonable to assume that most of the fires attended were either bushfires or had the potential, under more adverse circumstances, to develop into a bushfire.
- Twenty-six percent of fires were deliberate, comprising 39 percent of cause where the causes were known.
- Although the greatest number of fires occurred in the Brisbane region, fires were spread out across the state, with higher numbers of fires also occurring in the Tropical North Queensland, Northern and Hervey Bay–Maryborough regions.
- Almost six million hectares were burned in fires the QPWS attended in Queensland from 1999–2000 to 2003–04. However, these figures are strongly affected by large-scale fires that dominate the northern savannas of Cape York, where there is greatly reduced potential for damage, and where fires may be allowed to burn to fulfil ecological management goals. Fires of deliberate causes burned less than one percent of the total area. However, this statistic must be viewed in context of where the fires occurred, the ecological impact and the potential for loss of life or property.

Cause

Of the fires attended from 1999–2000 to 2003–04, 4.6 percent were incendiary with a further 21 percent labelled suspicious (Figure 104). Accidental (23%) and natural fires (8%) were the other principal causes of fires. The cause was unknown in roughly one-third of cases. Hence, deliberate causes accounted for 39 percent of cases were the cause of the fire was assigned.

The proportion of unknown causes varied substantially between seasons, from roughly 55 percent in 1999–2000 and 2000–01 to less than 20 percent in 2003–04, necessarily influencing the proportion of fires that were recorded as deliberately lit (Figure 103). In 2003–04, approximately 40 percent of fires were determined deliberate, whereas in previous years the value was around 20 percent. Deliberate causes typically accounted for between 30 and 50 percent of fires of 'known' cause in a given season. Natural fires were a comparatively small but important component during both the 2002–03 and 2003–04 seasons.

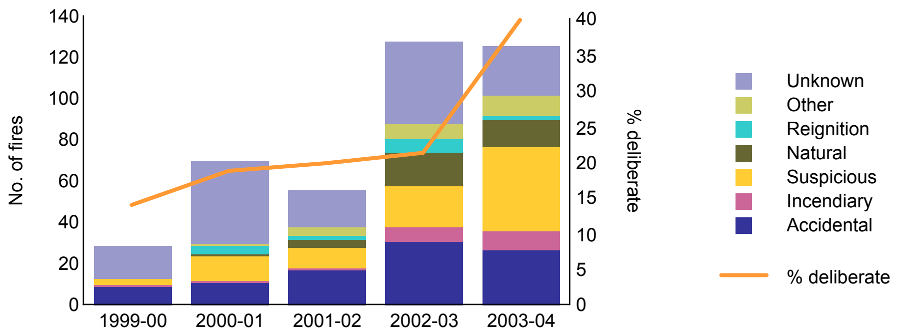
Specific ignition factors

The escape of non-QPWS burn offs was the leading cause of non-deliberate fires, accounting for 23 percent of all QPWS fires, being the largest single cause of fires after deliberate causes. This was a particularly important factor in both 2002–03 and 2003–04 (Figure 105).

Point of ignition: The point of ignition was indicated in 30 percent of cases. In 20 percent of all cases there was a single point of ignition, 4.2 percent related to multiple points of ignition on the same day and 3.7 percent involved multiple points of ignition over more than one day (Figure 106). It is unclear if this reflects the distribution of point of ignition types of the entire population.

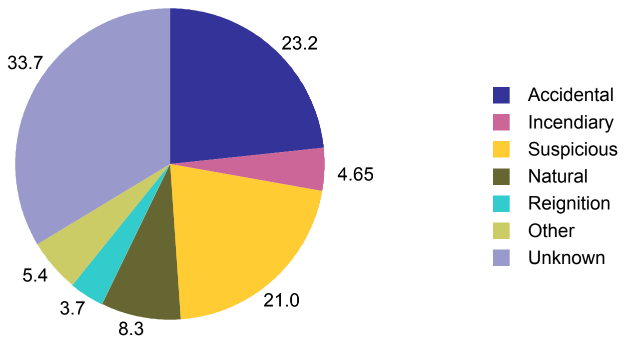
There is no definitive relationship between the patterns of ignition and the cause of fires, although specific causes appeared to be more commonly linked to one pattern of ignition than another. Fires that resulted from the escape of QPWS burns normally had multiple ignitions, either on a single day or over a longer interval (Figure 107). Escapes from non-QPWS burns exclusively resulted from multiple ignitions on the same day. Although lightning strikes may cause multiple points of ignition, the majority of natural QPWS fires were recorded as having a single ignition point. The majority of deliberate ignitions were also recorded as having a single ignition point. However, in six instances (6% of deliberate lightings) multiple points of ignition were recorded. These principally involved multiple ignitions on the same day. Although there is some uncertainty owing to the small number of cases where information is available, these results suggest that for at least six percent of fires the QPWS attended there was an intention of the fires spreading.

Figure 103: Cause, by year



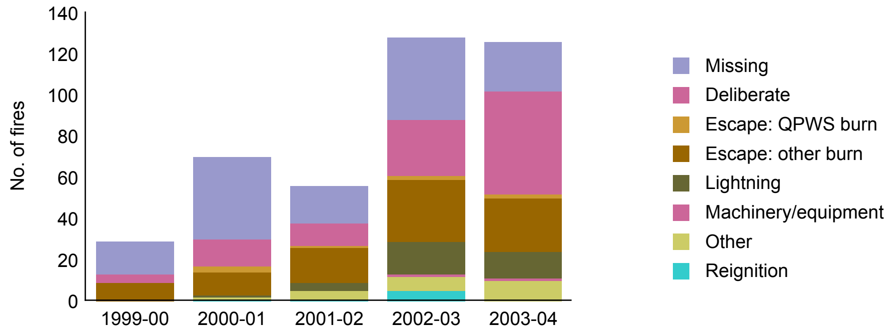
Source: QPWS 1999–2000 to 2003–04 [computer file]

Figure 104: Cause (percent)



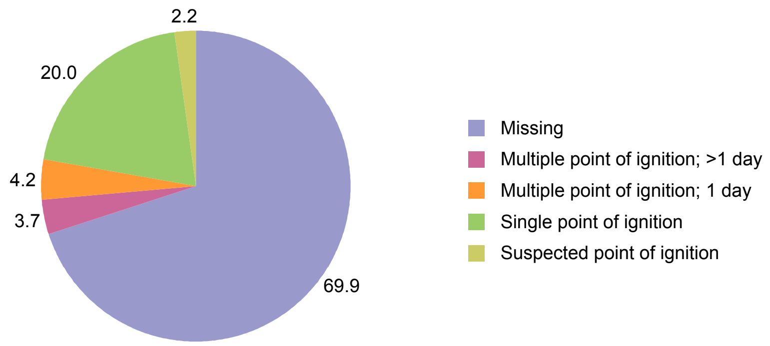
Source: QPWS 1999–2000 to 2003–04 [computer file]

Figure 105: Specific causes, by year



Source: QPWS 1999–2000 to 2003–04 [computer file]

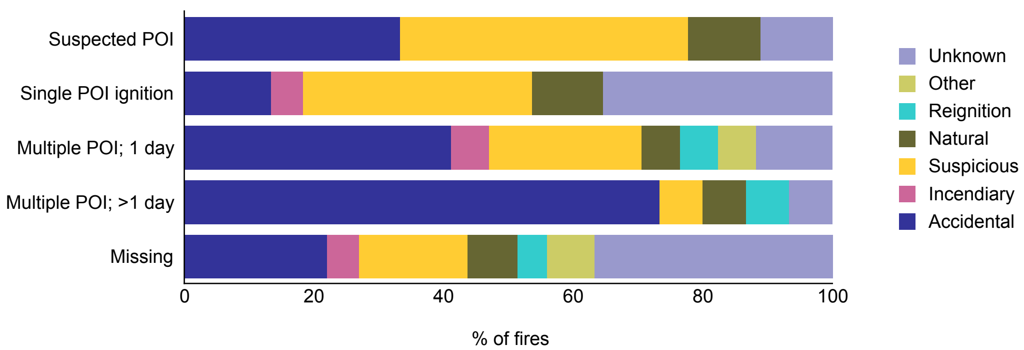
Figure 106: Points of ignition (POI)[a]



a: Multiple POI; >1 day = multiple points of ignition occurring over more than one day. Multiple POI; one day = multiple points of ignition occurring on the same day. Suspected POI = suspected point of ignition

Source: QPWS 1999–2000 to 2003–04 [computer file]

Figure 107: Causal distribution associated with each point of ignition type[a]



a: Multiple POI; 1 day = Multiple point of ignition all occurring on the same day; Multiple POI; >1 day = Multiple point of ignition all occurring on more than one day

Source: QPWS 1999–2000 to 2003–04 [computer file]

Location

Information about the location of fires includes the regional distribution of fires, as well as details about reserves and the tenure of lands on which most fires occurred.

Region

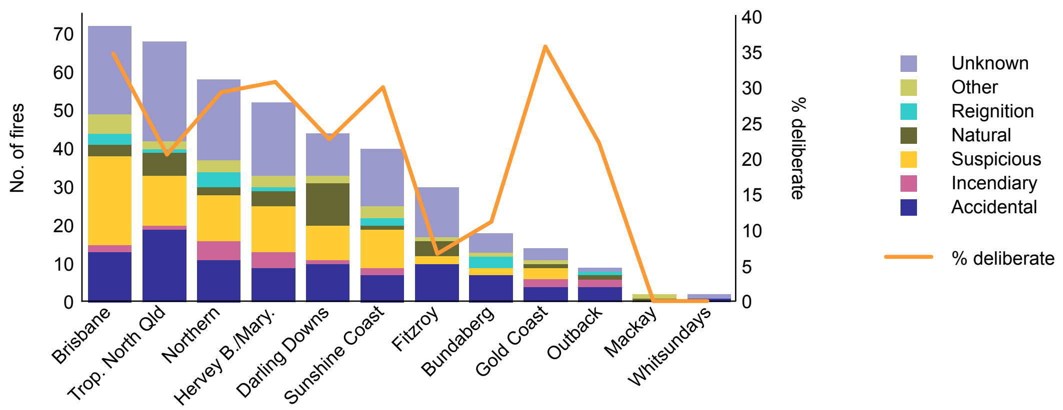
The distribution of QPWS-attended fires is necessarily restricted by the distribution of national parks and other nature reserves in Queensland, but for earlier years, it may also be influenced by data availability. Hence, the data presented in this section can only be used as a rough guide. The regions used in the QPWS analysis are equivalent to those used in the QFRS analysis (Figure 15).

In comparison to both the QFRS and FPQ, QPWS-attended fires were more evenly distributed across the state. The greatest number of fires occurred in the Brisbane region followed by the Tropical North Queensland, Hervey Bay–Maryborough, Darling Downs and Sunshine Coast regions (Figure 108).

The relative causes of fires varied markedly between regions. Deliberate causes accounted for approximately 20 to 30 percent of fires in most regions where total fire numbers exceeded 30 (Figure 108). The greatest number of deliberate fires occurred in the Brisbane region (n=25). A high proportion of fires in the Gold Coast region were also deliberate (35%), but the actual numbers of deliberate fires were low.

The greatest number of natural fires occurred in the Darling Downs (n=11), accounting for 25 percent of fires in that region. This observation is consistent with the FPQ data. Natural fires also accounted for a comparatively high proportion of fires in the Mackay (50%) and, to a lesser extent, Outback (11%) and Fitzroy (13%) regions.

Figure 108: Region, by cause



Source: QPWS 1999–2000 to 2003–04 [computer file]

Reserve

Some caution should be exercised when interpreting the data for individual parks, as the data for some reserves may be incomplete. Based on the available data, 11 aggregations experienced at least 10 or more fires (all causes) in five years, with the Bellthorpe, D'Anguilar South and Lumholtz Southern aggregations experiencing as many as 18 to 20 in that period. Of these, approximately one-third were deliberately lit. The greatest number of deliberately lit fires occurred in the Wondai and Paluma aggregations where they comprised 75 and 53 percent of fires respectively. Half the fires on Bribie Island were also deliberate lit.

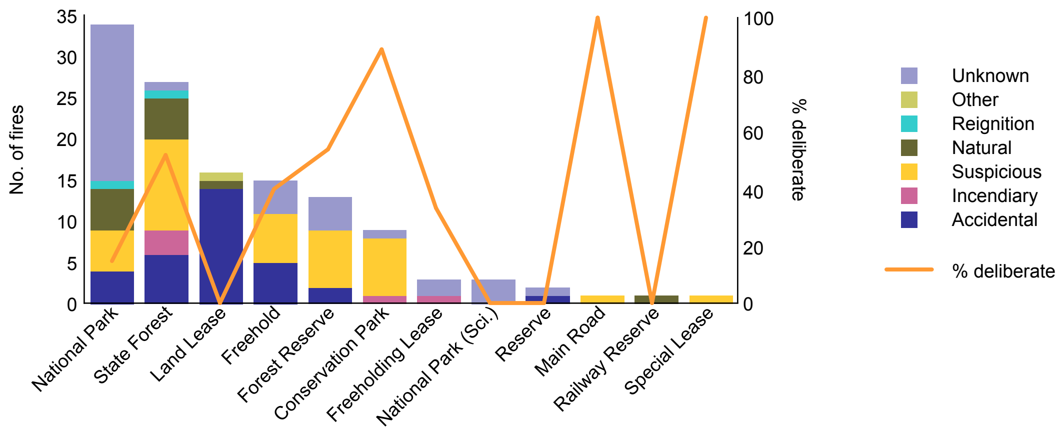
Tenure

Tenure was reported in 31 percent of cases, with unknown attributions being comparatively evenly spread between the non-deliberate, deliberate and unknown causes. Of those where tenure was indicated just over one-quarter occurred in national parks, just over one-fifth in state forests and a further 10 to 13 percent each in land lease, freehold and forest reserve categories. Marked differences in the principal cause of fires were natured across tenure types.

The greatest number of deliberate fires occurred in state forests, conservation parks and forest reserves, national parks, or freehold land (Figure 109). Distribution of deliberate fires between these locations may have been a function of both location and accessibility, but may also have depended on an individual's perception or regard towards land conservation status. Approximately one-half of all fires in state forests and forest reserves were deliberate. In the case of the latter tenure, deliberate fires were responsible for 78 percent of all causal attribution in that tenure type. In comparison, only 15 percent of fires in national parks were deliberately lit. Even taking into account the comparatively lower level of causal attributions in national parks, deliberate fires comprised only one-third of assigned causes, being substantially lower than for state forests. Nevertheless, deliberate causes were the only known cause of fires in conservation areas.

The greatest number of natural fires occurred in national parks and state forests, followed by land lease, tenure types that experienced the greatest numbers of fires generally. Accidental, natural and other causes were the only assigned origins for fires on property in a land lease arrangement.

Figure 109: Tenure, by cause



Source: QPWS 1999–2000 to 2003–04 [computer file]

Timing

The timing of fires is examined by week of the year and day of the week. No information was available regarding the time of day fires occurred.

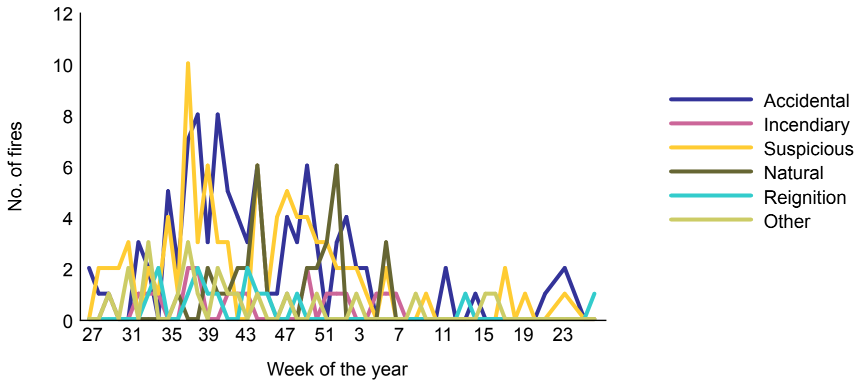
Week of the year

As for other jurisdictions, the QPWS attended the greatest number of fires from early September to late January (Figure 110), similar to the distributions evident for the FPQ and QFRS. Some differences in temporal distributions were evident based on cause. The greatest number of deliberate (principally suspicious) and accidental fires occurred in late September to early October, with lesser numbers of fires occurring through November and December. In contrast, most natural fires occurred in late December through to early February, although a spike in natural fires was also recorded in early October.

Day of the week

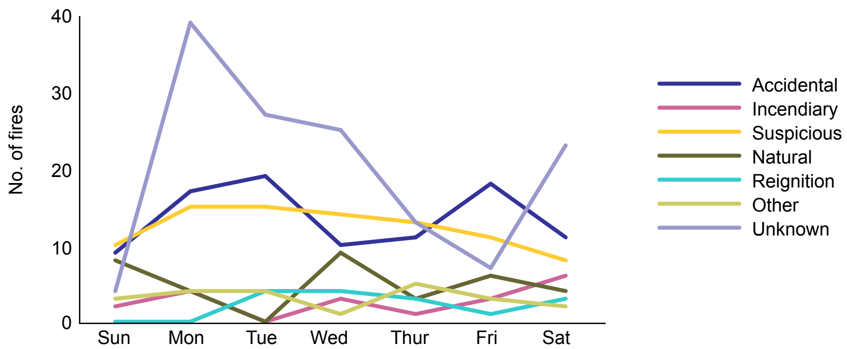
There was no evidence for increased fire frequency on weekends relative to weekdays for either deliberate or non-deliberate fires (Figure 111).

Figure 110: Week of the year, by cause



Source: QPWS 1999–2000 to 2003–04 [computer file]

Figure 111: Day of the week, by cause



Source: QPWS 1999–2000 to 2003–04 [computer file]

Area burned

In contrast, to the distribution observed for QFRS and to a lesser extent FPQ fires, comparatively few QPWS fires were less than five hectares. The vast majority of QPWS fires were 10 to 1,000 ha in size, with 100 to 500 ha being most prevalent (Figure 112). This may partially reflect incomplete reporting for the first few years of the period analysed; larger fires were more likely to be recorded. However, it also evident that land management agencies in other jurisdiction also tended to attend a greater number of moderate and larger fires than their rural and urban counterparts, reflecting differences in the environment in which they occurred, accessibility, etc. In addition, many larger fires in Queensland occurred in remote parts of the state, where there may be a delay in responding, or as is often the case in the northern savannas, where protection of life and property is not a consideration, fires are allowed to burn to achieve ecological outcomes. This is reflected in the large areas burned in the Tropical North Queensland region.

The same general size distribution outlined above was evident for most causal categories, but some differences were evident between different causes. Of note, deliberate causes accounted for a decreasing proportion of fires with increasing fire size (Figure 113). The vast majority of fires larger than 2,000 ha were either accidental or natural in origin, with both these causal categories tending to account for greater proportions of increasingly larger fires.

Almost six million hectares (5,936,509 ha) burned in QPWS-attended fires from 1999–2000 to 2003–04, with more than 800,000 ha burning every year. The total area burned peaked at 2.3 million hectares in 2003–04. Note that these figures included fires that the QPWS attended that lay outside its estate (QFRS, FPQ and other fires).

Accidental causes was a major contributor to the total area burned in all seasons, accounting for 70 percent of the total area burned in the state in the five year period. However, natural fires were a major contributor in both 2002–03 and 2003–04, burning just over one million hectares (18% of the total area burned). In 2003–04, natural fires accounted for 39 percent of the total area burned (Figure 114).

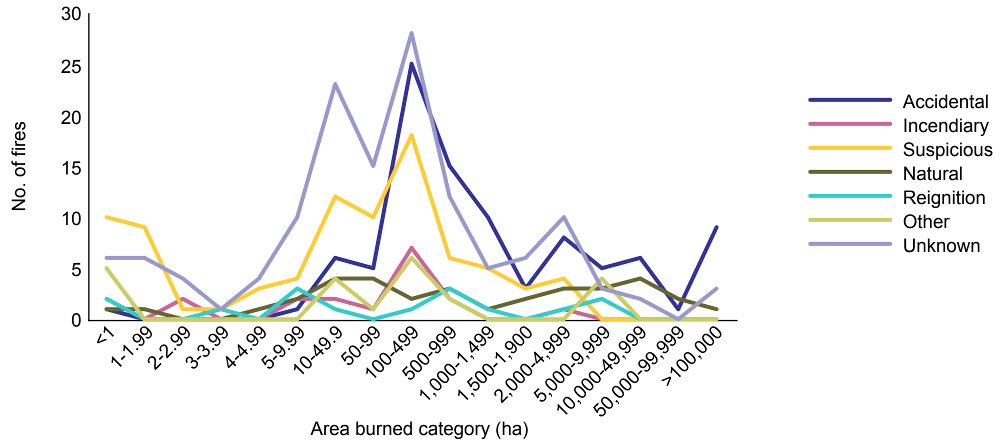
As the vast majority of fires greater than 100,000 ha occurred in the Tropical North Queensland region, it is not surprising that 86 percent of the total area burned was located in that region (Figure 115). This reflects the fact that vast areas of the tropical savannas in northern Queensland burn every year. There were 16 fires greater than 100,000 ha within the QPWS database from 1999–2000 to 2003–04. Eleven of those fires were located in Tropical North Queensland. The other three were in the Northern region, with one each in the Darling Downs and Fitzroy regions. In contrast, the majority of small fires occurred in coastal southeastern Queensland within the Brisbane, Sunshine Coast and Hervey Bay–Maryborough regions. These regions accounted for a decreasingly smaller proportion of fires as area category size increased. It is not valid to compare fire sizes burned in a savanna ecosystem with, for example, those experienced in Eucalypt forests and woodlands in southeast Queensland.

Owing to their smaller size, deliberate fires appeared to burn trivial areas of land in comparison to accidental and natural fires, accounting for just 0.6 percent of the total area burned (38,800 ha in total). However, it is necessary to take into account where those fires occurred: only 7,322 ha were burned by deliberate fires in the Tropical North Queensland region; a large number of all deliberate fires occurred in southeast Queensland; 7,769, 6,106 and 5,994 ha were burned by deliberate fires in the Brisbane, Darling Downs and Northern regions respectively; and 4,218 ha were burned by deliberate fires in the Gold Coast region (Figure 116).

Although the area was not large, deliberate fires were responsible for 35 percent of the total area burned in the Gold Coast region, 19 percent of the area burned in the Outback, and 21 percent of that burned in the Brisbane region. In other regions deliberate fires accounted for less than eight percent of the total area burned (Figure 116).

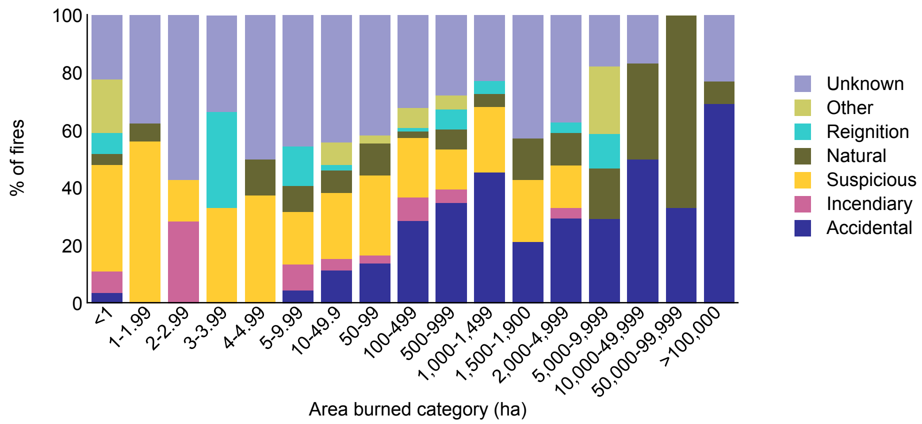
The largest deliberate fire on the Gold Coast burned 2,856 ha. In the Brisbane region, a deliberately lit fire burned 2,230 ha. The largest deliberately lit fire in the Darling Downs region burned 4,220 ha. In the Northern, Tropical North Queensland and Bundaberg regions, the largest deliberate fires burned 2,084, 1,936 and 3,141 ha respectively.

Figure 112: Area burned category, by cause (number)



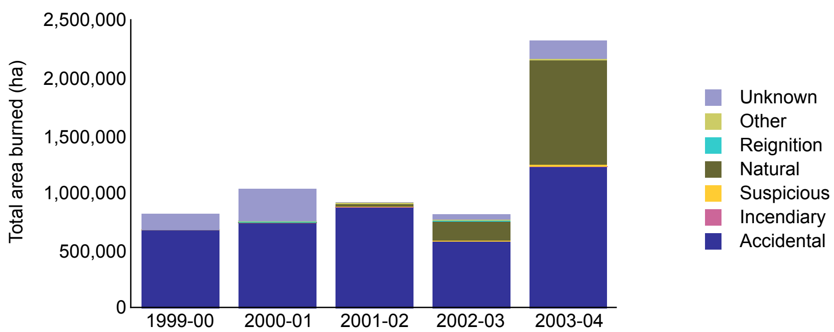
Source: QPWS 1999–2000 to 2003–04 [computer file]

Figure 113: Area burned category, by cause (percent)



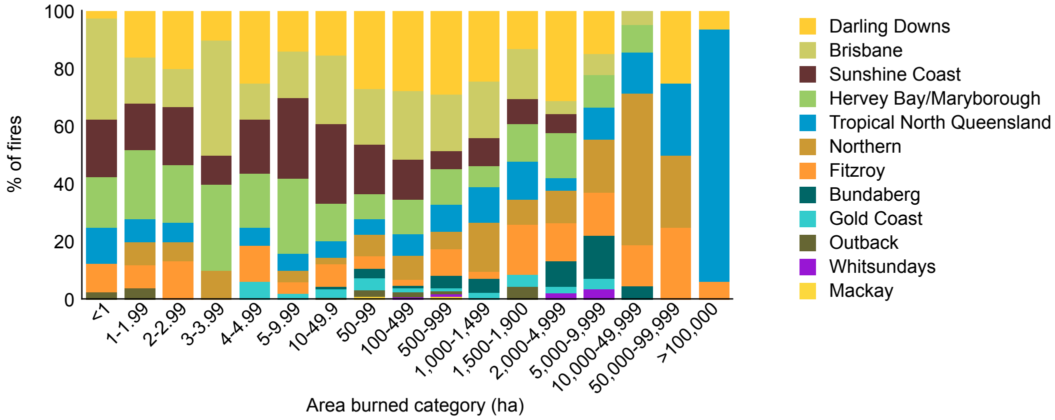
Source: QPWS 1999–2000 to 2003–04 [computer file]

Figure 114: Total area burned (ha), by cause each year



Source: QPWS 1999–2000 to 2003–04 [computer file]

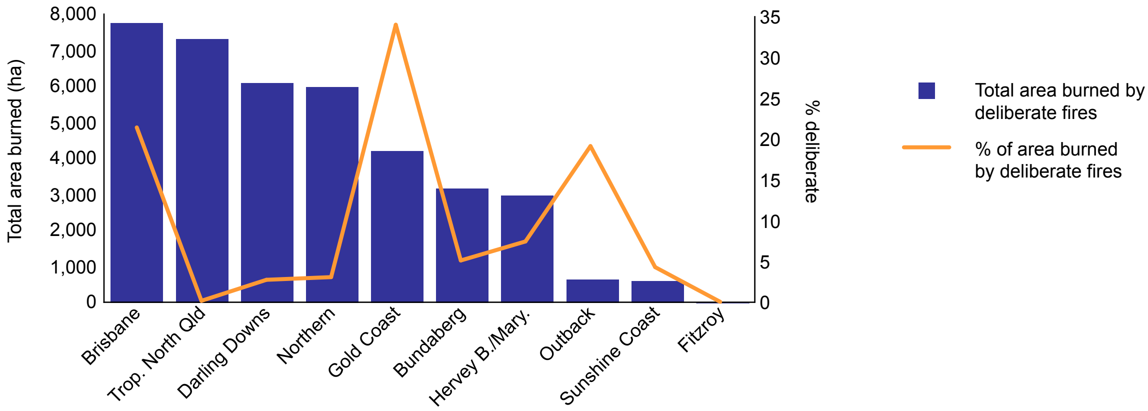
Figure 115: Area burned category, by region[a]



Note: a Refers to the regional distribution of fires within each area category; for example more than 80 percent of fires in the greater than 100,000 ha category occurred in the Tropical North Queensland region

Source: QPWS 1999–2000 to 2003–04 [computer file]

Figure 116: Area burned by deliberate fires in each region



Source: QPWS 1999–2000 to 2003–04 [computer file]

Summary

Important points about the incidence, cause, location, timing and type of fires attended by Queensland fire agencies are summarised below. Also included is information about the conditions under which the fires occurred.

Number of fires: Based on the data provided, there was an average of 12,650 vegetation fires in Queensland every year. This is lower than the average reported by the Australian Productivity Commission (APC 2007), as early QFRS data were incomplete. Nor does this figure include vegetation fires attended by rural brigades. Vegetation fires comprised between 54 and 67 percent of all fires attended by fire services in Queensland (APC 2007).

Less than two percent of documented cases of vegetation fires in Queensland occurred in state forests, national parks, and conservation and forest reserves. Most vegetation fires occurred in the urban and semi-urban environment, as summarised below:

- The **QFRS** attended an average of 9,105 vegetation fires per year for 1997–98 to 2001–02. This is a minimum as early data were incomplete; actual values are likely closer to 12,000 to 13,000 per year. The number of vegetation fires the QFRS attended in rural environments is unknown.
- The **FPQ** attended 3,531 vegetation fires from 1975–76 and 2003–04, representing an average of 122 fires per year, but up to 239 fires were attended in a given year.
- The **QPWS** attended an average of 127 vegetation fires in 2002–03 and 2003–04.

The number of fires individual land management agencies in Queensland attended may have changed markedly following implementation of the South East Queensland Regional Forests Agreement in December 1999.

The cause of fires Queensland fire services attended is summarised in Table 4. Important points about the cause of fires are further summarised below:

- The proportion of deliberate fires varied markedly between agencies, owing to different levels of causal attribution, but accounted for roughly 40 to 50 percent of cases where causal attributions were made.
- Natural fires were responsible for a higher proportion of fires land management agencies attended than urban fire services attended.
- Fires resulting from an open flame or spark accounted for 64 percent of fires the QFRS attended where the form of heat of ignition was determined. Between one-half and two-thirds of these related to use of matches. Most deliberate fires resulted from use of an open flame or spark, whereas the causes of non-deliberate fires were more diverse. Nevertheless, vegetation fires resulting from machinery, electrical equipment, and hostile fires were comparatively minor.
- The causes of accidental fires varied markedly for urban and land management agencies. Smoking-related materials and non-deliberate child fires were a major contributor to accidental fires in the urban environment (collectively accounting for one-quarter of known causes). For the FPQ, the principal accidental cause was cases where all reasonable care was taken (the actual activity contributing to the fire was not known). Within the QPWS data, the greatest single accidental cause related to burn offs conducted outside of QPWS tenures.
- Malicious incendiarism and torching of abandoned or stolen motor vehicles was a major problem for the FPQ in the Beerburrum region of southeast Queensland.
- Smoking-related materials were responsible for two percent of all vegetation fires the QFRS attended. This represented 12 percent of cases where the heat of ignition was delineated, and 14 percent of all non-deliberate fires the QFRS attended. They were responsible for one to three percent of all vegetation fires in any one region. In the Brisbane region, smoking-related materials were responsible for 18 percent of all fires where the heat of ignition was identified. In the majority of urban centres in regional Queensland, such fires contributed to seven to 11 percent of known heat of ignitions. No information was available about smoking-related fires attended by land management agencies.

- **Fires started by children**: The only information available for Queensland relates to non-deliberate fires started by children younger than 16 years of age. These comprised 2.4 percent of all vegetation fires the QFRS documented, but 12 percent of instances where the ignition factor (cause) was assigned. Few fires were started by children younger than six years of age; the numbers of fires started by the six to 12 and 13 to 16 year age groups were comparable. The numbers of non-deliberate fires attributed to children were correlated with the total number of fires recorded in a given year, and with the number of fires within that region generally. The diversity in the forms of heat of ignition and the complexes where fires occurred increased with age. In the case of the latter, the proportions of fires occurring at single dwellings decrease, and in parks, forests, reserves increase, as children become older. Most fires are lit during the bushfire season, comparable to the trends observed generally. More non-deliberate child fires occurred on weekends than on weekdays. The greatest numbers of fires occurred between 4 and 6 pm, principally reflecting weekday patterns.

The FPQ has recorded an increase in the number and proportion of deliberate fires in state forests and other reserves under its jurisdiction since the late 1980s. This is particularly evident for the Beerburrum region, an area that was increasingly affected by massive population growth. It is not possible to draw conclusions about long-term changes in the incidence of deliberate fires from either the QFRS or QPWS data.

Location: Vegetation fires are heterogeneously distributed at regional and district levels as well as within individual postcodes. Most vegetation fires (all causes) documented for Queensland occurred near major urban centres, with approximately half occurring in the Brisbane region alone. Other areas to experience comparatively high numbers of fires included the Gold Coast, Fitzroy and Northern regions. High numbers of fires were also observed within specific locations within individual regions (such as the Outback region).

Within the Brisbane region, fire frequencies were lowest in the centre of the metropolitan area, and tended to increase outwards. The greatest density of fires occurred in the Logan City, Ipswich City and Caboolture Shire (Part A) statistical region sectors, areas that lie on the outer margins of the rapidly expanding urban development.

The maximum number of fires recorded in a postcode was commonly greatest in those statistical region sectors that, overall, recorded the highest numbers of vegetation fires. Moreover, many postcodes within that statistical region sector recorded elevated numbers of fires. Postcodes with the highest numbers of postcodes accounted for the highest proportion of all fires within a region. The maximum number of vegetation fires recorded in a single postcode, and the proportion of vegetation fires hosted within high fire frequency postcodes, overall, declined as the number of vegetation fires recorded in the statistical region sector decreased.

Overall, the number of vegetation fires increased with increasing population; individual postcodes typically recorded between one and 100 vegetation fires per 10,000 people per year, with the maximum rate being comparatively constant across postcodes with high varying population sizes.

The distribution of fires land management agencies attended was governed by the distribution of lands under their jurisdiction, but there was also an intimate relationship with population distributions; for example, the FPQ attended the greatest number of fires in the Beerburrum (near Caboolture) district, while the QPWS attended the greatest number of fires in the Brisbane region. For both agencies, those areas reporting the highest numbers of fires overall, also tended to record the highest proportion of deliberate fires.

Timing: Information about the week of the year, day of the week, and time of day fires occurred is summarised below.

Week of the year: most fires Queensland fire agencies attended occurred between August and January, with peak numbers occurring in September. However, subtle differences existed between agencies, namely:

- **QFRS**: most fires occurred from early August to late November with a peak in September. However, with peak frequencies occurring over a shorter period than for land management agencies. The timing of non-deliberate and deliberate fires was comparable but varied between seasons.
- **FPQ**: most human-caused fires occurred from mid August to mid January, with peak numbers occurring in September. However, the timing of fires varied between regions; for example, peak numbers of fires in the Dalby and Roma regions occurred around December–January. Timing also varied between seasons.
- **QPWS**: fires occurred from September to late January, peaking in September.

Day of the week:

- **QFRS**: 35 and 52 percent more deliberate fires occurred on Sunday and Saturday respectively than the weekday average; 25 to 29 percent more non-deliberate fires also occurred on Saturday and Sunday; non-deliberate child fires were 70 percent higher on a weekend than on a weekday.
- **FPQ**: 34 percent more deliberate fires occurred on Sunday and 26 percent more deliberate fires on Saturday than on the average weekday. The degree of weekend bias varied between regions.
- **QPWS**: no weekend bias was observed.

Time of the day: Information about the time of day fires occurred is summarised for the QFRS and FPQ below:

- **QFRS**: Deliberately lit fires peaked between 3 and 6 pm with 37 percent occurring between 6 pm and 6 am; non-deliberate fires peaked between 12 and 3 pm with 24 percent occurring between 6 pm and 6 am. Many fires in the Outback region occurred at night; 44 percent and 17 percent of deliberate fires occurred between 6 pm and 6 am, and midnight and 6 am, respectively. Deliberate fires occurring at night were also an issue in the Brisbane region, although to a lesser extent than observed in many other state capitals.
- **FPQ**: peak numbers of non-deliberate fires occurred between 11 am and 4 pm, whereas the peak for deliberate fires was 3 to 4 pm. This is marginally earlier than observed by the QFRS. Greater numbers of deliberate as compared with non-deliberate fires occurred at night, although interpretation is hampered by the delay between time of ignition and detection for many fires that occurred at night. Deliberate causes of fire at night included both malicious incendiarism and torching of abandoned or stolen motel vehicles. Both were particularly problematic in the Beerburrum region.

Area burned: The majority of vegetation fires were small. Typically the number of fires attended decreased as the size of the fire increased, but size distribution varied between agencies; the QFRS attended a higher proportion of small and very few large fires, whereas the QPWS and to a lesser extent FPQ recorded greater numbers of moderate and large fires (a reflection of the environment, suppression capabilities, access, environment benefits, etc.).

Data about the total area burned (where, when, how) are dominated by the largest fire events. The largest fires occurred in the northern half of the state (Tropical North Queensland, Northern regions) larger fires in the south tended to occur further inland (for example, Dalby). Most large fires were of natural, accidental or unknown origins; deliberate fires tended to account for a decreasing proportion of fires as fire size increased. Hence, deliberate fires burned comparatively smaller areas than did other causes. This in no way takes into account the impacts, costs and potential dangers deliberate fires pose. Although large areas have been burned during droughts concurrent with El Niño events, the disproportionate data contribution from the large savanna fires makes it difficult to assess any systematic relationship between weather and bushfires in Queensland. This does not mean it does not exist; rather the relationship with the total area burned is not necessarily systematic.

It was impossible to establish the total area burned within Queensland for a particular period due to the potential duplication of fire data across agencies, an absence of rural data and because of the limited temporal overlap between the available databases. Statistics about the total area burned by fires attended by each agency are summarised below:

- **QFRS** fires from 1997–98 to 2001–02 burned 2,166,640 ha, with the greatest total area burned in 1998–99; incendiary fires accounted for 1.6 percent and suspicious fires 9.7 percent of the area burned by fires of known causes.
- **FPQ** fires from 1975–76 to October 2004 burned 1,580,444 ha, with the greatest total area burned in 1982–83, 1989–90 and 1994–95; 18 percent of this was burned by fires of deliberate (principally suspicious) origin.
- **QPWS** fires from 1999–2000 to 2003–04 burned 5,936,509 ha, with the greatest total area burned in 2003–04; less than one percent was burned by fires of deliberate causes.

Type of incident: The type of vegetation fire incidents attended may vary markedly across fire services depending on their responsibilities and the environment in which they operated (for example, urban versus land management) as summarised below:

- A high proportion of fires the FPQ and QPWS attended could be classified as a bushfire or had the potential to develop into a bushfire under more adverse conditions.
- The types of incidents attended by the QFRS were variable; 30 percent of fires attended were small vegetation fires, 30 percent grass fires, 33 percent scrub, bush and grass fire mixtures, and six percent were classified as other vegetation/outside fires.
- The proportion of all fires the QFRS attended that were occurred in scrub, bush, grass mixed and solely grass environment, combined, was comparatively uniform across regions of Queensland; that is, the data were not simply biased by those locations that recorded the most fires.
- The QFRS data indicate that the principal causes of fires were broadly similar across different incident types (small vegetation fires, grass fires, forest/woodland, etc.), although slightly higher percentages of deliberate fires were recorded for fires that occurred in 'scrub, bush, grass mixed' and 'orchards/vineyard/nurseries'.
- Most fires the QFRS attended occurred on unused property or Crown land (34%), followed by parks, forests and reserves (19%), and around road complexes (roads, lots, etc.; 13 percent).

Bushfire danger: The greatest number of fires in the urban environment occurred under conditions of moderate bushfire danger with the number of fires decreasing as fire danger increased. This occurred irrespective of cause. The greatest number of all fires the FPQ attended were also under conditions of moderate bushfire danger, but most deliberate fires occurred when there was a low fire danger index. Deliberate causes accounted for decreasing proportions of fires with increasing fire danger index. This reflects contributions from higher proportions of night-time fires, but also differences in daytime fires.

The proportion of fires under conditions of high to extreme fire danger varied between regions. Greater proportions of fires under these conditions principally reflected increasing contributions from non-deliberate causes. However, those areas that documented the highest number of fires generally accounted for the greatest proportion of all fires that occurred under the most adverse conditions.

Table 4: Summary of fire cause for each fire agency					
Agency	**% unknown**	**% incendiary**	**% suspicious**	**% deliberate (known)**	**% natural (known)**
QFRS	79.3	1.6	7.6	9.2 (45)	0.8 (3.9)
FPQ	28.0	19.8	16.4	36.2 (50)	12.4 (17)
QPWSa	33.7	4.6	21.0	25.6 (39%)	8.3 (12.5)

a: 1999–2000 to 2003–04

Source QFRS 1997–98 to 2001–02 [computer file]; FPQ 1975–76 to October 2004 [computer file]; QPWS 1999–2000 to 2003–04 [computer file]

Sources of information

ABS 2006a. *Australian demographic statistics*. ABS cat. no. 3101.0. http://www.abs.gov.au/ausstats/abs@.nsf/cat/3101.0

ABS 2006b. *Australian standard geographical classification (ASGC): digital boundaries, 2006: statistical region sectors*. ABS cat. no.1259.0.30.002. http://www.abs.gov.au/ausstats/abs@.nsf/cat/1259.0.30.002

ABS 2005a. *Population by age and sex, Queensland*. ABS cat. no. 3235.3.55.001. http://www.abs.gov.au/ausstats/abs@.nsf/cat/3235.3.55.001

ABS 2005b. *Tourism region maps and concordance files, Australia, 2005*. ABS cat. no. 9503.0.55.001. http://www.abs.gov.au/ausstats/abs@.nsf/cat/9503.0.55.001

ABS 2001a. Australian standard geographical classification. ABS cat. no. 1216.0. http://www.abs.gov.au/ausstats/abs@.nsf/cat/1216.0

ABS 2001b. Postal Area to Statistical Local Area Concordance, Australia, 2001. ABS cat. no. 1253.0. http://www.abs.gov.au/ausstats/abs@.nsf/cat/1253.0

ABS 2001c. 2001 Census Community Profile Series: 4510 (Postal area of usual residence). Accessed through http://www.censusdata.abs.gov.au

ABS 2001d. 2001 Census Community Profile Series: 4551 (Postal area of usual residence). Accessed through http://www.censusdata.abs.gov.au

ABS 2001e. 2001 Census Community Profile Series: 4560 (Postal area of usual residence). Accessed through http://www.censusdata.abs.gov.au

APC 2007. *Report on government services 2007, part D: emergency management*. http://www.pc.gov.au/gsp/reports/rogs/2007/emergencymanagement/index.html

Australia. Department of Environment and Heritage 2001a. *Land use: Queensland*. Accessed through: http://audit.deh.gov.au/ANRA/atlas_home.cfm

Australia. Department of Environment and Heritage 2001b. *Native vegetation types and extent: Queensland*. Accessed through: http://audit.deh.gov.au/ANRA/atlas_home.cfm

Australia. Department of Natural Resources and Water 2000. *A guide to fire management in Queensland: incorporating fire management theory and departmental practice*. http://www.nrw.qld.gov.au/land/state/pdf/fire_management_guide.pdf

Australian Bureau of Meteorology 2007a. *Average minimum and maximum temperature maps: Queensland*. Accessed through: http://www.bom.gov.au/climate/map/temperature/IDCJCM0005_temperature.shtml

Australian Bureau of Meteorology 2007b. *Average rainfall, annual: Queensland*. Accessed through: http://www.bom.gov.au/cgi-bin/climate/cgi_bin_scripts/annual-monthly-rainfall.cgi

Australian Bureau of Meteorology 2007c. *Fire seasons in Australia*. Accessed through: http://www.bom.gov.au/climate/c20thc/fire.shtml

Ellis S, Kanowski P & Whelan R 2004. *National Inquiry into Bushfire Mitigation and Management*. Canberra: Commonwealth of Australia. http://www.coagbushfireenquiry.gov.au/findings.htm

Murphy M, Nicolopoulos N & Sandinata V 1997. *Socio-economic characteristics of communities and fires*. Statistical research paper; issue 4, Sydney: NSW Fire Brigades

QPWS 2001. *An Aussie battler: the eastern bristlebird*. http://www.epa.qld.gov.au/publications/p00058aa.pdf/An_Aussie_battler_the_eastern_bristlebird.pdf

Queensland Police Service 1978–79 to 1998–99. *Queensland Police Service statistical review*. Brisbane: Queensland Police Service

Western Australia

Contents

The first part of this chapter provides **contextual information** on Western Australia, including basic information about its climate, geography, land use and population. It also provides an outline of the bushfire regimes, historically important bushfire events, and an overview of fire services in Western Australia. The second part represents an **analysis of data** provided by the Western Australian Fire and Emergency Services Authority (FESA) and the Western Australian Department of Conservation. Although FESA attends many types of fire incidents, and those data were supplied, this analysis exclusively refers to vegetation fires, unless otherwise indicated.

For an explanation of the key terms, limitations and methodology refer to the introduction, glossary and methodology chapters.

Introduction

Western Australia covers an area of 2,529,880 square kilometres, occupying the western third of the Australian mainland; it is bordered by South Australia and the Northern Territory in the east, the Southern Ocean to the south, the Indian Ocean to the West and the Timor Sea to the north.

Geography

Western Australia includes some the most ancient rocks and landscapes preserved on Earth, a factor that together with the climatic conditions shapes the distribution of fauna and flora and ultimately its people. Most of the state lies on a low plateau (400 m above sea level) that has exceptionally low relief, and no surface runoff. This plateau descends rapidly, sometimes via an escarpment, to the narrow coastal plain.

The far north is dominated by the Kimberley Plateau, bordered to the south by the King Leopold Ranges, and dissected by the Fitzroy and Ord rivers (Figure 1). Southeast of the plateau lies the rugged and arid landscape of the Pilbara, including the red ridges and gorges of the Hamersley Ranges. The latter contain vast reserves of iron ore, being the principal reason for establishment of small towns and settlements throughout the region, with a most notable settlement at Port Hedland. The highest point in Western Australia, Mount Meharry (1,251 m) is located nearby. Many of the coastal rivers in the northwest may be dry for much of the year but become raging torrents during cyclones. Nearer the coast, rivers ebb and flow with the large tidal variations. 'Rivers' further inland drain away from the sea into saline lakes within the Great Sandy and Gibson Deserts.

To the south of the Hamersley Ranges lies the Gascoyne River, beyond which lie the ancient rocks and landscapes of the Yilgarn Block. The west the Yilgarn Block is bounded by the Darling Fault separating the plateau of the shield from the coastal plain. The capital of Western Australia, Perth, and numerous other settlements lie on this plain, in the southwest corner of the state.

The southwest contains the state's only permanently flowing streams and true forests. It is also the most populated region in Western Australian outside of the metropolitan city of Perth. The Great Victorian Desert dominates the southeast of the state, south of which is the waterless, treeless Nullarbor Plain. The southern coast is bounded by unbroken, sheer cliffs beyond which lies the Southern Ocean.

Figure 1: Map of Western Australia

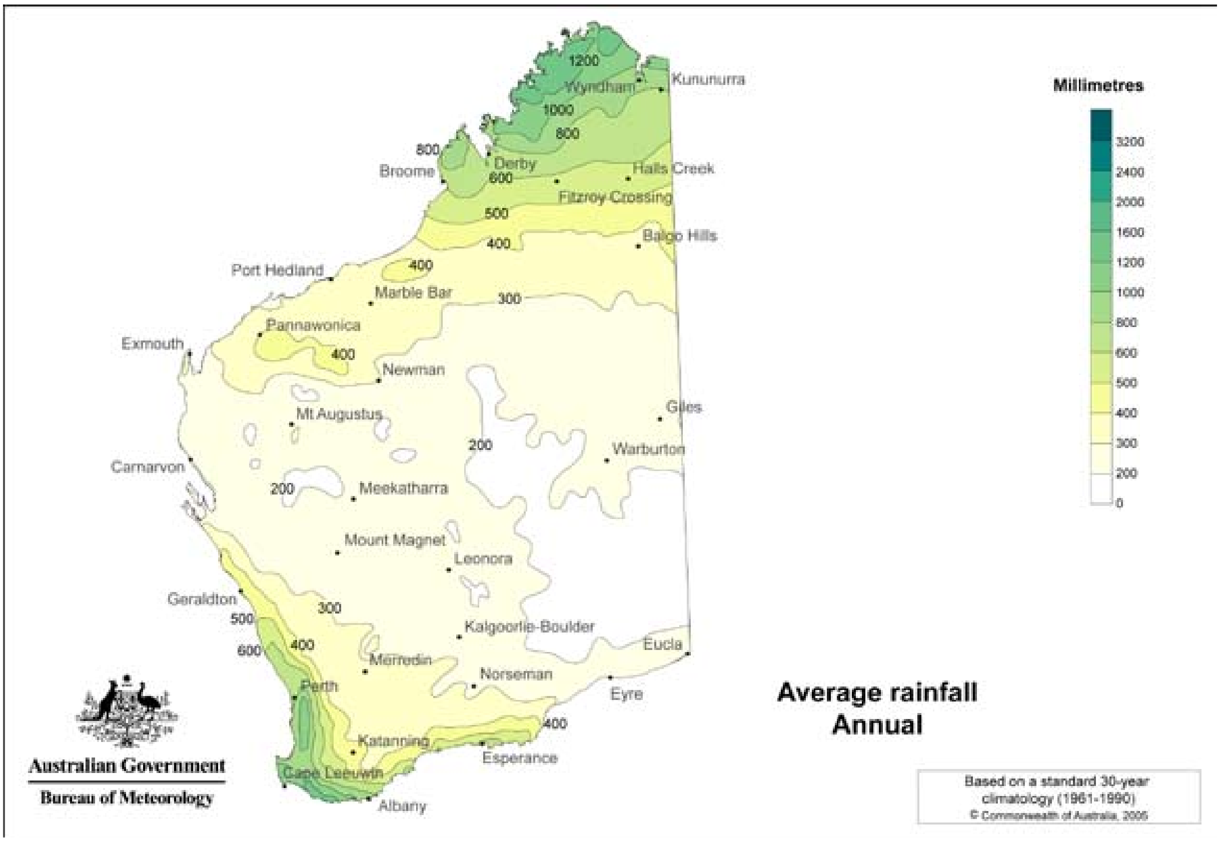
Climate

Climate varies markedly both north–south and east–west across the state. The Kimberley region in the north has a tropical, hot monsoonal climate, receiving 500 to 1,500 mm annually. Almost 85 percent of the State's runoff occurs in this area. However, this heavily rainfall is restricted to the wet season, and there is almost an absence of rainfall in the dry season, which spans from April through to November. Tropical savannas dominate the north of the state and owing to the extreme weather conditions and typically infertile soils this area is sparsely populated.

The southwest corner, covering an area of 140,000 square kilometres, is characterised by a temperate Mediterranean climate; summers are warm to hot and dry, winters are cool and wet. Owing to the concentration of rainfall by mountains near the coast, the far southwest corner receives as much as 1,400 mm per year (Figure 2).

Rainfall sharply decreases inland, with the central four-fifths of the state being semi-arid or desert; receiving only 200 to 250 mm per year. As well, rainfall in these parts is erratic, as it is commonly related to cyclone activity across the northern half of the state during the summer months (Australian Bureau of Meteorology 2007a).

Figure 2: Average annual rainfall for Western Australia



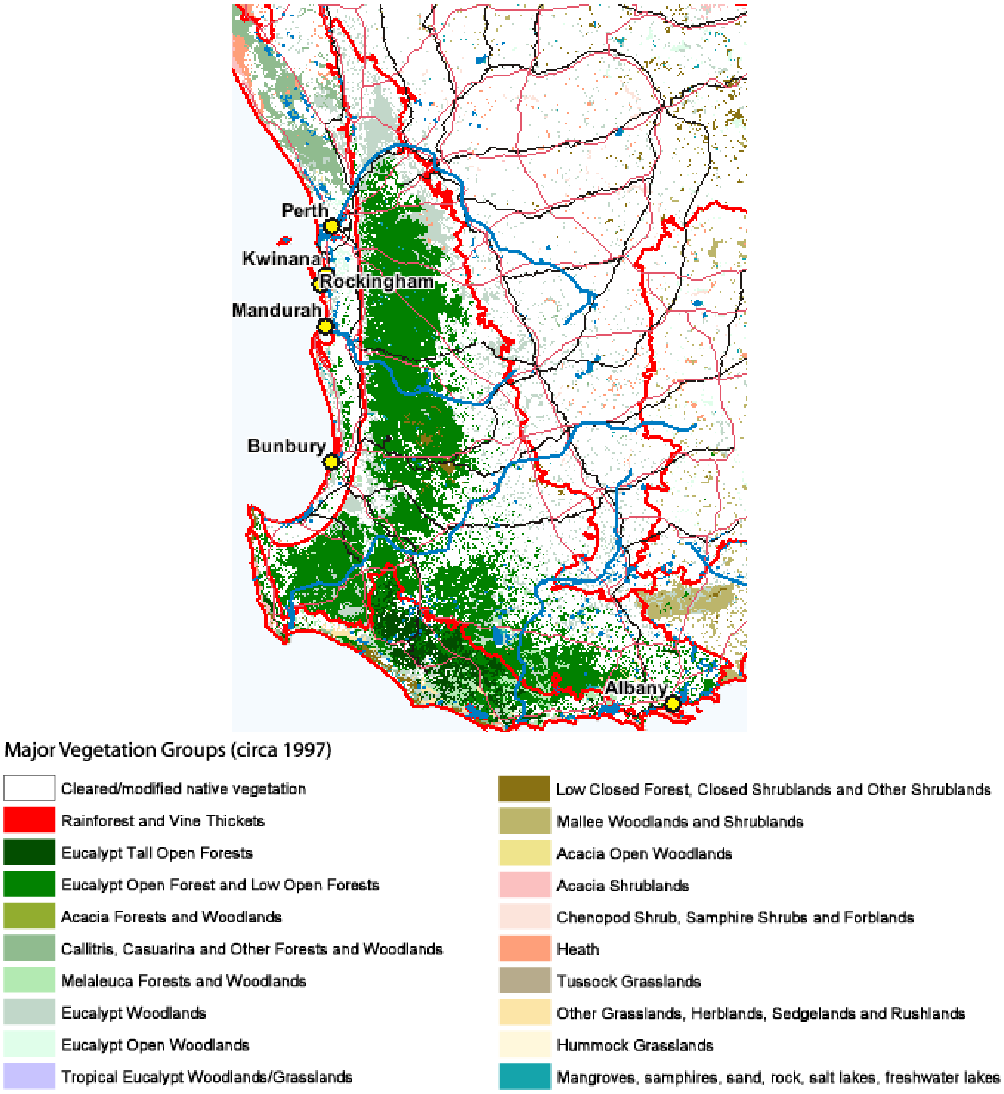
Source: Australian Bureau of Meteorology 2007a
© Australian Bureau of Meteorology

Native vegetation

Vegetation types vary markedly across Western Australia. The Kimberley region is sparsely wooded savanna. Distinctive features include ubiquitous spinifex and moisture-storing baobab (bottle) trees. The Great Sandy Desert to the south is sparsely vegetated by spinifex, with some acacia scrubland (mulga) in the swales. The remainder of the arid interior is dominated by large expanses of hummock grassland, tussock grassland, chenopod (saltbush, bluebush), and samphire shrublands.

The southwest of Western Australia represents one of the top nine habitats for terrestrial biodiversity in world. There are more than 7,000 species of indigenous vascular plants, more than 2,400 of which are endemic to the area. Originally much of the southwest was heavily forested, including large stands of karri (eucalypt), one of the tallest trees in the world. Although some forests remain, much of the southwest plateau has been cleared or modified for agricultural purposes. This has placed enormous strain on biodiversity; more than 800 species of vascular plants are rare or threatened, with 50 species already having become extinct. Of the remaining vegetation, there are abundant eucalypt forests and woodlands (including jarrah, marri and wandoo), often with a rich understorey (Figure 3). Other vegetation includes species-rich shrublands, heath, Agonis shrublands, Banksia low woodlands, swamps dominated by paperbark and swamp yate (Australia. Department of Environment and Heritage 2001b).

Figure 3: Native vegetation groups – southwest Western Australia (c. 1997)



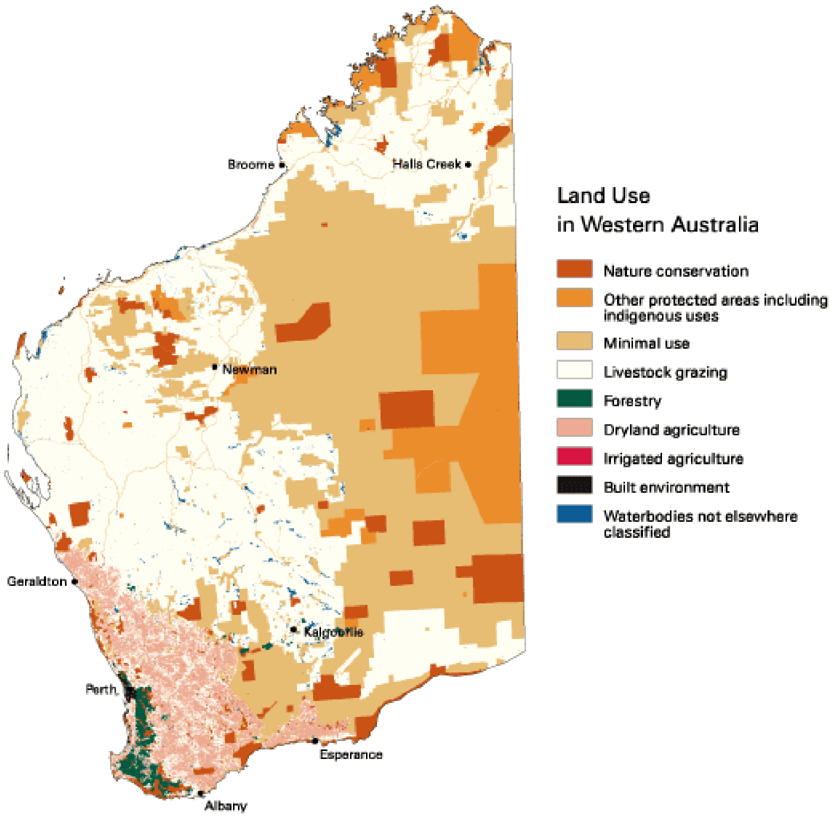
Source: Australia. Department of Environment and Heritage 2001b

Land use

As at 1996–97, agriculture accounted for a little less than half the total area of Western Australia. Dryland agriculture occurred in five percent of the state, but was principally located in the moister southwest corner (Figure 4). Approximately 89 percent of agricultural land (42 percent of the state) was used for grazing of native pastures. This was concentrated in the north and in a broad swathe that extended from the northwest to the southeast of the state. Principal agricultural products included wheat, wool, beef and lamb, but there was a diverse range of products generated, including other broadacre crops, horticulture, orchard and vineyards.

Approximately 92 million hectares (36% of the state) are minimal use areas that are largely vacant Crown land concentrated in the arid interior of the state. Traditional indigenous uses cover 23 million hectares (9%) of the state. Nearly 17 million hectares (7% of the state) is used for nature conservation, covering a range of environment types. Most of the area falls strictly within nature reserves. Forestry, including softwood timbers and woodchips from natural forests and plantations, principally occurs in southwest Western Australia (Australia. Department of Environment and Heritage 2001a).

Figure 4: Land use (c. 1996–97)



Source: Australia. Department of Environment and Heritage 2001a
© Department of Environment and Heritage

Population

As at June 2006, Western Australia had a resident population of 2,050,900, accounting for 10 percent of Australia's population (ABS 2006). The overwhelming majority of people live in the temperate southwest corner of the state, with almost three-quarters (73.5%) of the state population residing in the Perth statistical subdivision (SSD). Major regional centres in Western Australia include Mandurah, Bunbury, Geraldton, Kalgoorlie, Albany, Broome, Port Hedland, Karratha and Carnarvon. Western Australia is exceptionally rich in natural resources, and the location of townships in areas outside of the southwest is strongly correlated with the distribution of natural resources; these include mineral deposits of gold, nickel, iron and diamond, as well as oil reserves, fishing and pearling, and agriculture/forestry.

The median age of Western Australia's population in 2005 was 36.2, marginally lower than the national average of 36.6 at that time (ABS 2005a). Children aged 0 to 14 years accounted for 19.9 percent of the population. The largest proportion of children within the age group occurred in the Kimberly (26.2%) and the Pilbara (25.9%) regions. Approximately 14.4 percent of the state's population is Indigenous, although in central and northern Western Australia, Indigenous people account for 35 to 60 percent of the population (ABS 2005a).

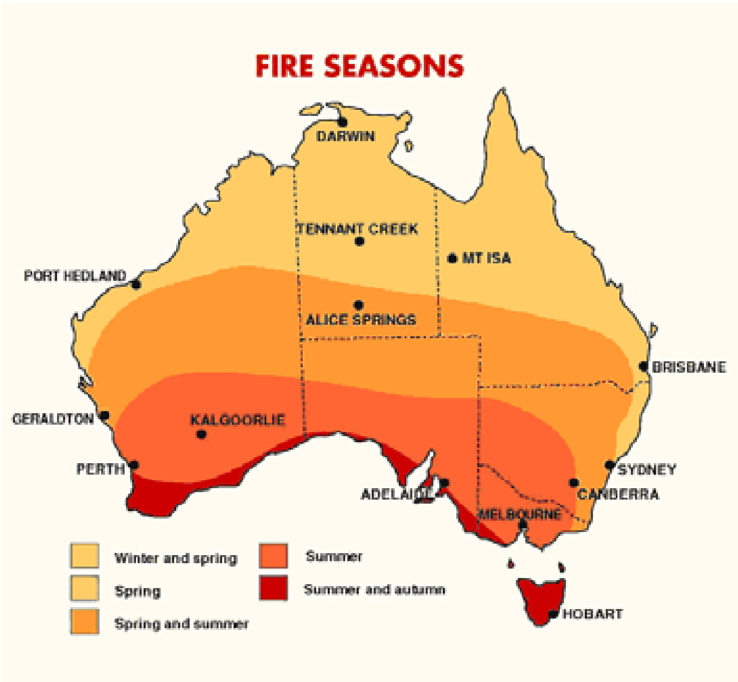
Bushfire regimes

Fire regimes – that is, the intensity and the frequency of fires, the season in which they occur, their spatial pattern or extent, and their type – vary markedly across Western Australia as result of the inherently large diversity in climate, and hence ecology, population distributions, and land use patterns.

Due to significant latitudinal variations in climate Western Australia can potentially experience bushfires in any month of year. In the southern half of the state fires are most common in summer months but may extend into spring or autumn depending on the latitude, whereas the northern savannas experience widespread burning during winter and spring, with the predominance of spring burning increasing away from the equator (Figure 5).

In the Kimberley, vast tracts of the savannas are burned every year through natural fires, land management practices and to some extent, as a result of arson. The nature, timing, significance, and areas burned by savanna fires are discussed in detail in the Northern Territory chapter; such factors are also pertinent to the savanna fires of northern Western Australia. Many savanna fires occur in remote areas where firefighting, if it should be required, comes under the jurisdiction of landholders or local government and volunteer agencies. It is difficult to accurately assess the role of deliberate fire setting in these areas owing to the remoteness of the locations, the routine nature of burning practices and natural fires, and the fact that firefighting agencies do not actively attend many fires in these areas.

Figure 5: Timing of bushfire seasons in Australia



Source: Australian Bureau of Meteorology 2007c

Bushfire history

Major bushfire events and bushfire seasons in Western Australia are summarised in Table 1, with the 1960–61 and 2002–03 being discussed in more detail below:

1960–1961: represents one of the most disastrous bushfire seasons in Western Australia's modern history. A series of large devastating wildfires occurred over much of the southwest, including at Mayanup, Pemberton, Shannon River and Kudardup (near Margaret River), but the most notable occurred at Dwellingup. Although this region had experienced drier than average conditions, the fires in southwest Western Australia were ostensibly associated with movement of a tropical cyclone across the northern part of the state. Development of a stationary strong high pressure system east of the cyclone resulted in temperatures above 40ºC over five days and strong northeasterly winds in the southwest part of the state. On 19 January Dwellingup experienced dry thunderstorms as the cyclone moved slowly along the coast. Lightning started a series of fires. These rapidly spread due to the hot, windy conditions. Rains on 24 January eased the fire situation, but not all the fires were fully extinguished. Even stronger winds associated with the passage of another cyclone across the north, reignited fires in the southwest, and Dwellingup in particular, a month later (24 February). These fires subsequently consumed a number of towns in the southwest, including Pinjarra, Holyoake, Nanga Brook, Marrinup and Banksiadale, with the loss of 132 houses, but no loss of life. A total of 134,000 ha were burned in the Dwellingup fires, but approximately 1.5 million hectares were burned during that season. Investigations into the Dwellingup fires ultimately shaped subsequent fire management in Western Australia.

Cyclones played an intimate role both in ignition and reignition of the Dwellingup fires. This is not a unique situation in Western Australia, with cyclones also playing an intrinsic role in the cause and spread of the 1937 and 1978 bushfires in the southwest (Australian Bureau of Meteorology 2007b).

2002–2003: Exceptionally dry conditions associated with drought conditions over four to five consecutive years led to the most severe fire season since 1960–61. There was a six-fold increase in lightning-caused fires across the state, and many regions experienced extended periods of very high and extreme bushfire weather conditions. The Department of Conservation and Land Management (now Department of Environment and Conservation) reported an eight-fold increase in the average area burned over the last 20 years, with 140,000 ha being burned in the southwest and 2.1 million ha burned in total. Major fires occurred near Esperance (Cape Arid National Park), Ravensthorpe, Jurien Bay and Cervantes, on the south coast, and in the Mount Cooke area, southeast of Perth (Ellis, Kanowski & Whelan 2004).

Table 1: Fire history of Western Australia

Date	No. of deaths	Area of fire (ha)	Losses	Location(s)
1925	1			Katanning
1930	1			Northam
1940	1			Katanning
1948		278 fires		Not known
1949		527 fires		Many fires caused by locomotives of the Railways Department and private timber mills
1951		23,000	Forest trees	Dwellingup, Manjimup district, various parts of southwest corner
1960–1961		>1,500,000	132 houses, 2 service stations, 3 shops	Dwellingup (134,000 ha), Mayanup, Pemberton, Shannon River and Kudardup
1974–1975		29,000,000		East and northeast of Kalgoorlie
2003		15,545,000		Cape Arid National Park, Ravensthorpe, Jurien Bay, Cervantes, Walpole Wilderness Area, Mount Cooke, Kimberley and Desert Region

Source: Ellis, Kanowski & Whelan 2004

Fire services

The structure of fire fighting agencies in Western Australia has changed markedly since June 1997 when the Western Australian Government established a taskforce to look at ways of improving planning and coordination across Western Australia's emergency services. Broadly, fire services fall under two arms, the Fire and Emergency Services Authority of Western Australia, and the Western Australian Department of Environment and Conservation, although a number of internal divisions exist under the FESA umbrella.

The **Fire and Emergency Services Authority (FESA)** of Western Australia was formally established as a statutory government authority on 1 January 1999, replacing both the Fire Brigades Board and the Bush Fires Board, bringing together the Fire and Rescue Service, and the Bush Fire Service, the State Emergency Service, Volunteer Marine Rescue Services, Emergency Management Services and Community Safety Services.

The Operations Services division within FESA incorporates two components – the Fire and Rescue Service of Western Australia (career and volunteer) and bush fire brigades (volunteer). Career firefighters within the Fire and Rescue Service operate from 20 fire stations in metropolitan Perth and five regional centres – Bunbury, Geraldton, Albany, Kalgoorlie and Mandurah – providing coverage for the most densely populated regions in Western Australia, although coverage excludes some outer Perth suburbs (such as Ellenbrook and Baldivis). The Volunteer Fire and Rescue Service (FRS) operates in many major country towns, and the volunteer Emergency Service Units (ESU) that are an amalgamation of the FRS, Bush Fire Service (BFS) and State Emergency Service (SES), undertake combined emergency management roles. Most of the outer metropolitan and country local government areas establish, subsidise and manage local bush fire brigades.

FESA provides fire appliances through a statewide fleet resourcing program on a replacement basis. FESA has developed a training program for local government to implement while FESA officers deliver specialised training and provide local government annual operating grants to provide essential operational equipment, including personal protective equipment. These brigades operate in regional areas of the state; their responsibilities include fire suppression (but not prevention) works on unallocated Crown land outside town sites. FESA has prevention and response responsibility for town sites, and increasingly there is coordinated delivery of fire services, with other fire services through ESU. If asked, FESA Operational Services staff may take responsibility for bushfires that exceed the capability of the local bush fire brigades, with a formal handing over procedure occurring when a predetermined trigger is reached.

As at 2002, there were more than 2,500 volunteer firefighters in more than 100 volunteer FRS brigades, and 25,000 volunteer firefighters in other volunteer brigades across Western Australia. As in other jurisdictions, volunteer fire fighting services, supported by career FESA managers, provide coverage for the greatest total but least populated areas of the state. Further information about FESA can be found at http://www.fesa.wa.gov.au.

The **Western Australian Department of Environment and Conservation (WADEC**: formerly the Department of Conservation and Land Management) is responsible for managing fires in or near national parks, nature reserves, state forests and other lands for which it has responsibility, including private lands managed by WADEC. Further information about WADEC can be found at http://www.naturebase.net.

This analysis incorporates both FESA and WADEC data although it is recognised that owing to the reporting arrangements, the FESA analysis does not incorporate all fires that occurred or were reported by FESA, as discussed below.

Fire and Emergency Services Authority (Western Australia) analysis

Background about the FESA dataset and its analysis

Although all fires attended by career FRS units, volunteer FRS units, ESU, etc., are reported to and recorded by FESA, the method of reporting and recording fire data varies somewhat between these services. All fires attended by career fire units operating from fire stations are recorded immediately within the AIRS database structure, and details of that fire are immediately available to FESA. This is not necessarily the case for ESU, volunteer FRS or bush fire brigade units. Typically the latter will notify FESA headquarters that a fire has occurred or been attended, but actual details of the fire may not be included within FESA's AIRS database until some later time. For some units this may be up to a year later, at the end of the financial year, with data being retrospectively entered into the database.

The data used in the following analysis incorporates only two components, namely:

- Total wildfire numbers for the period from 2000–01 to 2006–07 (sourced independently from FESA, and denoted as FESA for the 'source' in figures and in the text), to provide an overview of total vegetation fires numbers in Western Australia and thereby enable some consideration of the causal analysis undertaken below. This data also demonstrates the marked change in the number of fires that have occurred since introduction of a targeted arson reduction scheme in the 2000–01 to 2001–02 periods. It should be noted that this data would only include fires where suppression activities were undertaken and would not include fires that were merely monitored, even though the existence of such fires may have been reported to FESA at the time of their occurrence.
- Detailed data for causal analysis for the period 1997–98 to 2001–02. This data is in an AIRS database format and was submitted by FESA (denoted as AFAC–FESA in figures and text). This data is dominated by fires attended by career FRS fire units in major urban centres, but also appears to include some data submitted by volunteer FRS, volunteer bush fire brigades and ESU units in other parts of the state. It is emphasised that this data is incomplete, representing approximately one-half to two-thirds of all vegetation fires FESA recorded for the observation period. This data is probably most incomplete for more remote, sparsely populated regional areas. There can be discrepancies when using the FESA data, depending on the date of the data analysis, as local government only needs to report the number of fires FESA attended at the conclusion of the financial year. Most local governments are linked to the FESA-managed 000 call out system and the information is recorded immediately; however, it must be acknowledged that a number of calls are made to local FRS and not to the 000 network. Hence, it is possible that some local government data were not included within the data previously incorporated into the AFAC database. Although these AFAC–FESA data are incomplete, it does provide a broad guide to the trends for vegetation fires in Western Australia, trends that are overall consistent with those observed in other jurisdictions.

The AFAC–FESA vegetation fire data for 1997–98 to 2001–02 were not internally consistent over this period owing to changes in the coding and hence the classification of fires (Figure 6). This change in coding occurred shortly after FESA was established as a statutory government authority, and likely because of the transfer from a FESA database to the AIRS database structure. All statistics that used information about causal attributions in the following analysis used fire data from 2000–01 and 2001–02 fires only. In a limited number of cases, an alternative classification scheme was used to examine data for the five-year period from 1997–98 to 2001–02. This was principally undertaken to enable a more comprehensive guide to temporal variations. However, it should be noted that differences existed between the way in which the 2000–01 to 2001–02 and the 1997–98 to 2001–02 data are classified; the 2000–01 to 2001–02 incorporated all fires classified as wildfires (AIRS Type of Incident code = 160 to 179), whereas the 1997–98 to 2001–02 vegetation fires pertain to all fires where the vegetation variable was 0 to 99 (referred to as the alternative wildfire definition). The number of cases where there was a lack of correspondence between these two vegetation fire definitions was small (see methodology chapter).

Addition points about the FESA analysis for 2000–01 to 2001–02 are outlined below:

- The data were classified using Australian Incident Reporting System (AIRS) classification codes.
- The cause of fires was defined using the ignition factor variable.
- Deliberate fires include all fires classified as incendiary (AIRS ignition factor code = 110 or 120) or suspicious (AIRS ignition factor code = 210 or 220).
- Natural vegetation fires refer to all fires where the ignition factor codes were 800 to 890, incorporating any fire resulting from a natural condition or event. For FESA the breakdown of specific causes of natural fires was: high wind 9.7 percent, lightning 20.0 percent, high water (including flood) 0.9 percent, and any other natural condition (not classified [NC]/insufficient information to classify further [IO]) 69.3 percent.
- The dataset supplied included the form of heat of ignition variable.
- Smoking-related fires were classified based on: 'Form of heat of ignition' = 'Heat from smokers' materials' (AIRS codes 300 to 390). The cause of smoking-related fires was 40 percent accidental, three percent incendiary, 26 percent suspicious, and 29 percent unknown.
- All fires started by children were identified within the database as resulting from children playing and therefore were considered non-deliberate or accidental in origin. No information was available about the number of malicious fires started by children, as these fires were classified as incendiary or suspicious within the ignition factor variable, and cannot be delineated from other fires, included within these categories.
- The database included information about the 'type of incident'.
- Regions used in the FESA analysis were based on ABS (2005b) tourism regions. However, there was not an exact correspondence between tourism regions used in this analysis and ABS tourism regions. In this study, assignation was based on the highest levels of concordance between postcode (provided) and tourism region, but ABS tourism regions were constructed from smaller statistical areas that potentially crosscut suburb and postcode boundaries.
- Statistical subdivisions (SSDs) and statistical local areas (SLAs) were used to examine distribution of fires in specific areas of Western Australia. Although the general structure and terminology used for SSDs and SLAs follows ABS guidelines (ABS 2001a), again fundamental differences existed between the SSD and SLA used in this report and that defined by the ABS. SLAs were generated from the highest levels of concordance between postal areas and SLAs using ABS (2001b) guidelines. In contrast, SLAs the ABS used crosscut postal areas and postcodes. In this analysis SSDs were generated from the SLAs generated using the above method.
- The dataset supplied did not include information about the area burned.
- Information was available about the fire danger or fire restrictions at the time the fire occurred.

For more detail about these methodologies see the methodology chapter.

Overview

Fires the FESA attended can be summarised as:

- FESA attended 61,446 vegetation fires from 2000–01 to 2006–07, with the number of fires annually decreasing from a high of roughly 12,000 in 2000–01 to a low of approximately 6,500 in 2005–06 (Figure 7). Fires FESA documented accounted for about 95 percent of all fires attended in Western Australia in a given year. The numbers of fires documented in the AFAC–FESA database were comparatively stable from 1997–98 to 2001–02 (based on alternative wildfire definition; Figure 6), although these data were incomplete. The AIRS data available for causal analysis (derived from AFAC for the 1997–98 to 2001–02 data above) included 6,962 vegetation fires for 2000–01 and 6,984 vegetation fires for 2001–02, representing 59 and 62 percent of all vegetation fires FESA documented.
- Based on the summarised data FESA provided for the 2000–01 to 2006–07 interval, 94 percent of all fires attended were classified as scrub or bush and grass mixture fires, with a further 3.5 percent being classified as small vegetation fires, and 1.3 percent were grassfires. Only 0.2 percent of fires attended were forest or wood fires greater than one hectare in size.
- Collectively, deliberate causes accounted for 68.5 percent of all fires (8.6% incendiary; 59.9% suspicious), representing 77 percent of known causes of vegetation fires (restricted to 2000–01 to 2001–02 data only).
- The greatest number of documented fires occurred within the Perth region, which accounted for 93 percent of fires where the causal data were examined, and a minimum of 54 percent of all fires attended by fires agencies in Western Australia.

Cause

Detailed causal information was restricted to the 2000–01 to 2001–02 interval (Figure 6). Of these, 8.6 percent were classified incendiary with a further 59.9 percent being regarded suspicious in origin. Collectively, deliberate fires accounted for 76.7 percent of known causes of vegetation fires analysed (Figure 8). Accidental causes were responsible for 14.8 percent of fires. Natural causes accounted for just 1.6 percent. That high level of deliberate fires occurred in Western Australia during this interval is supported by the WADEC data for the same period; subtly lower rates of deliberate lightings for WADEC-attended fires likely reflects a greater proportion of natural and accidental fires in the nature parks and reserves and the greater distance of many of the WADEC lands from significantly populated areas.

Overall, the documented causes of fires remained comparatively stable across the two years (Figure 9). Subtle differences were, however, evident in the ratio of incendiary to suspicious fires.

Specific ignition factors

Form of heat of ignition: Of the roughly 80 percent of cases where the heat of ignition contributing to vegetation fires were identified for 2000–01 and 2001–02, 60 percent were caused by open flames (Figure 10). This reflects the significant role that deliberate fire setting played in Western Australian bushfires, with open flames being responsible for three-quarters (76%) of all deliberate fires but just 34 percent of non-deliberate fires (Figure 11). Of those fires identified as having been started by open flames, the use of matches outweighed lighters by roughly 2.5 to one (Figure 12).

The numbers of fires started by mechanical (fuel powered), electrical, hot objects/friction or hostile fires were small (Figure 10). However, collectively, such fires comprised 20 percent of all non-deliberate fires (Figure 11). One-third of all non-deliberate fires were smoking-related.

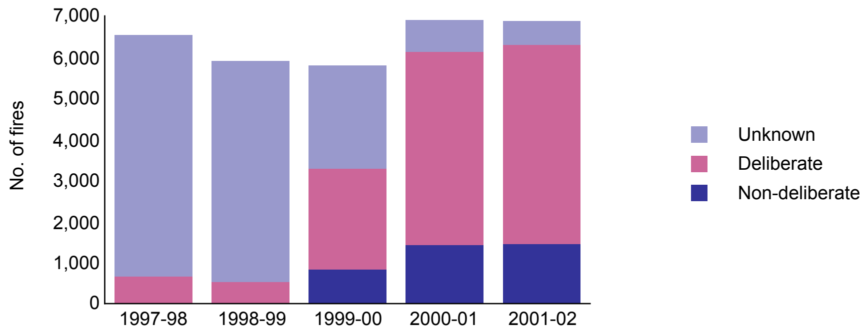
Fires started by children: Children 16 years and younger were identified as being responsible for 370 non-deliberate fires or 2.7 percent of all documented fires for 2000–01 to 2001–02. The low number and percentage of non-deliberate child fires likely reflects the fact that many fires attributed to children were considered malicious and hence classified as either incendiary or suspicious.

Almost three percent of child fires were lit by children five years and under, 13 percent by 6 to 12 year olds and 18 percent by 13 to 16 year olds (Figure 13). In two-thirds of cases the age of the child was not indicated.

The majority of non-deliberate child fires involved use of an open flame (Figure 14), although other causes contributed to a greater proportion of fires for older age groups. Use of matches was documented more frequently than was lighters and other materials (Figure 15). Although absolute numbers were small, and therefore may have been unrepresentative, an increase in smoking-related fires was evident with age.

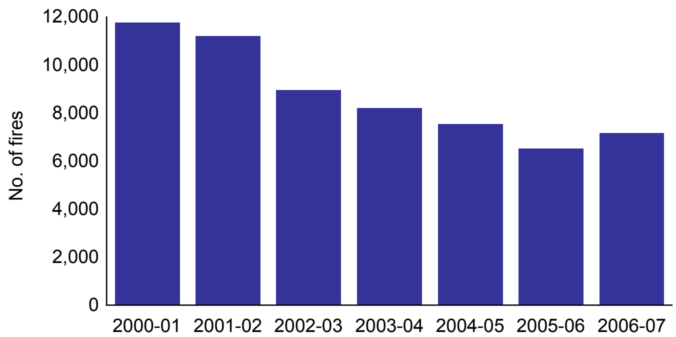
Smoking-related fires: A total of 1,631 fires in two years were documented as smoking-related, comprising 11.7 percent of fires documented in the AFAC–FESA database. Sixty percent of smoking-related fires were classified non-deliberate, 38 percent deliberate, and two percent unknown according to the criteria used in this study (Figure 16).

Figure 6: Number and cause of vegetation fires annually (number), 2000–01 to 2001–02



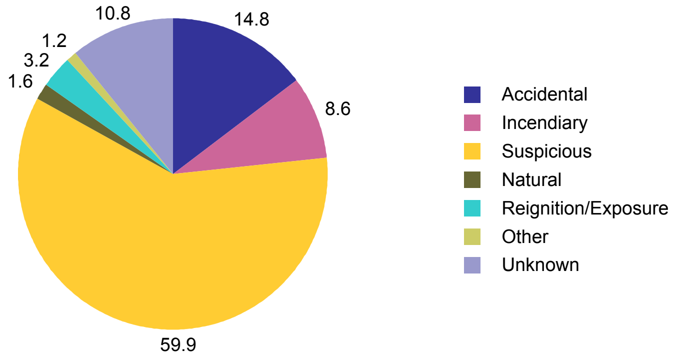
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 7: Number of vegetation fires annually (number), 2000–01 to 2006–07



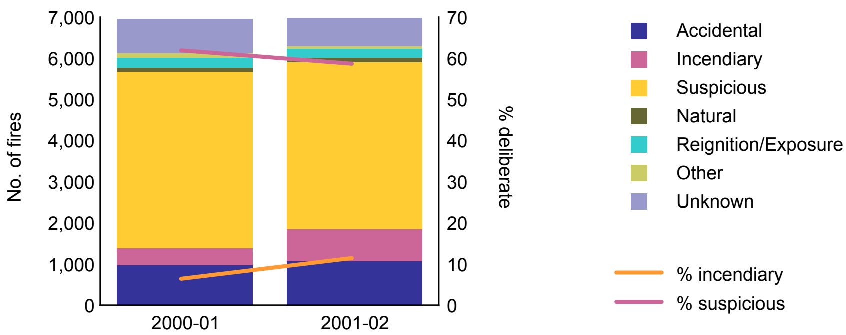
Source: FESA 2000–01 to 2006–07 [computer file]

Figure 8: Cause of vegetation fires (percent), 2000–01 to 2001–02



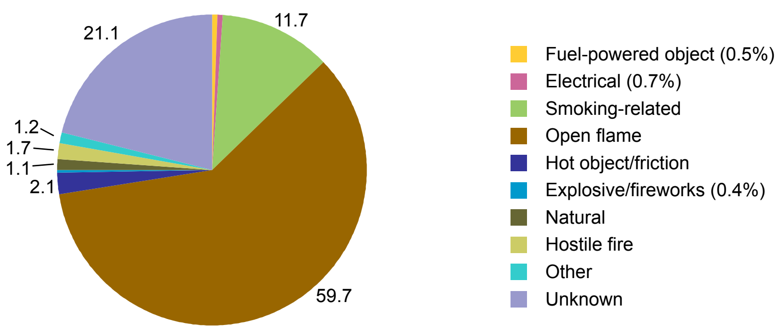
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 9: Cause of vegetation fires, each year, 2000–01 to 2001–02



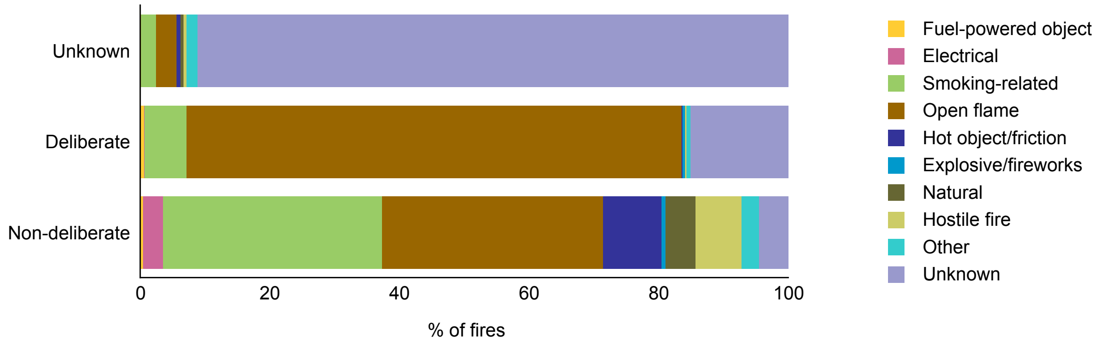
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 10: Form of heat of ignition (percent), 2000–01 to 2001–02



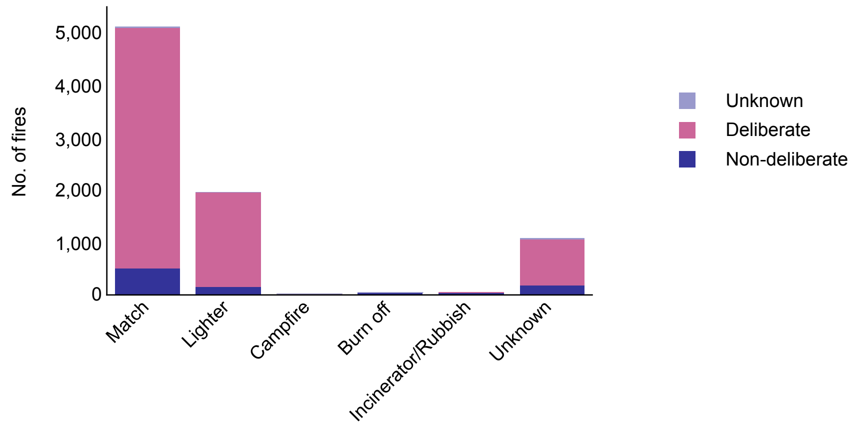
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 11: Form of heat ignition, by cause (percent), 2000–01 to 2001–02



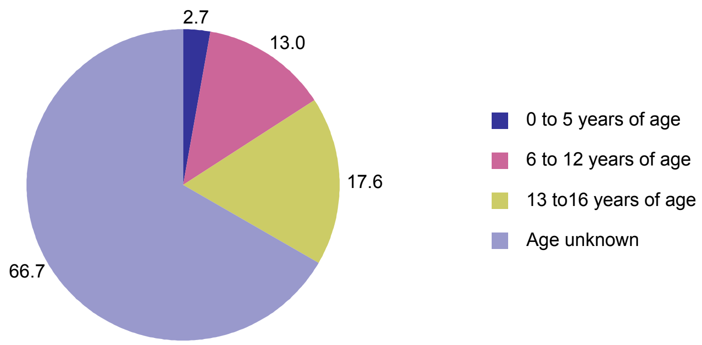
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 12: Form of heat of ignition, for fires started by an open flame (number), 2000–01 to 2001–02



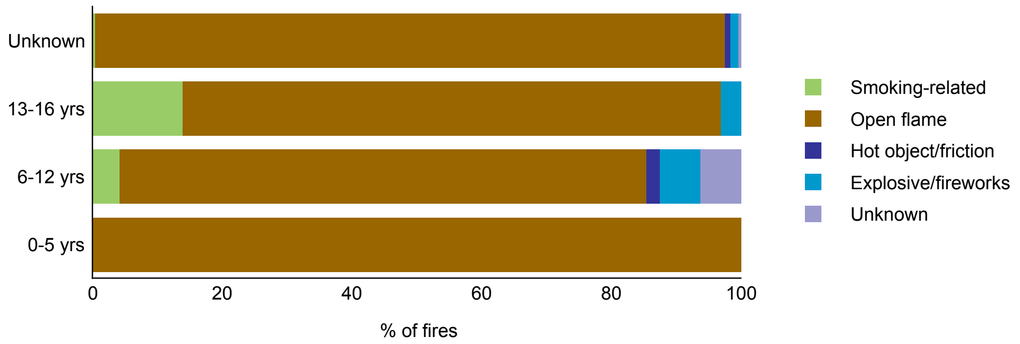
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 13: Non-deliberate child fires, by age (percent), 2000–01 to 2001–02



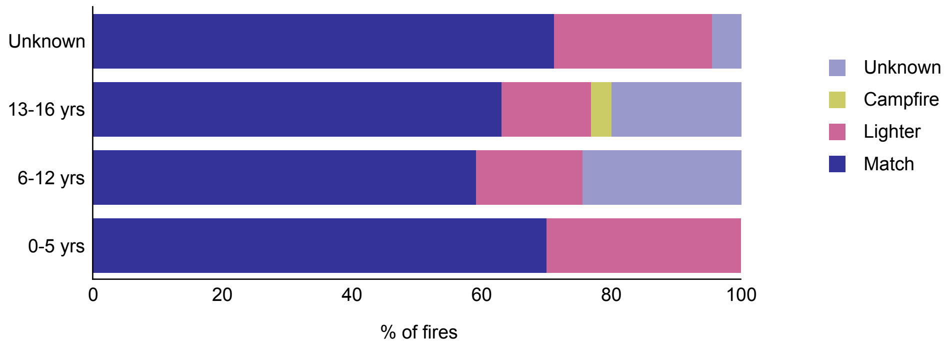
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 14: Form of heat of ignition for non-deliberate child fires, by age (percent), 2000–01 to 2001–02



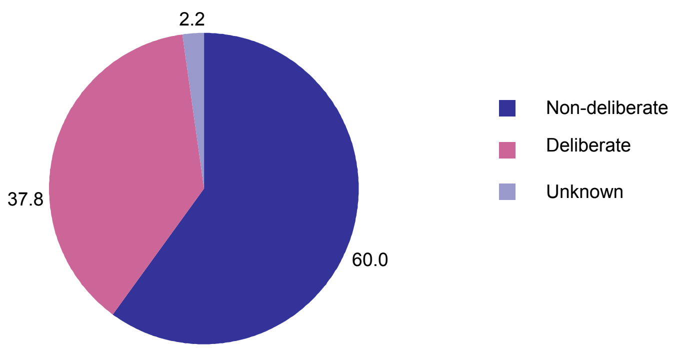
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 15: Specific form of heat of ignition used in non-deliberate child fires started by an open flame, by age (percent), 2000–01 to 2001–02



Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 16: Classification of smoking-related fires (percent), 2000–01 to 2001–02



Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Location

The location of AFAC–FESA vegetation fires was examined in terms of the region in which they occurred, and the concentration of fires, both absolute and relative to the population density in individual postcodes within the Perth region.

Region

Of the 13,946 vegetation fires documented in the AFAC–FESA database, 90 percent were in the Perth region, with a further 2.4 percent and 2.1 percent being located in the Coral Coast and South West regions, respectively (Figure 17; Figure 18). This emphasises the strong bias of the AFAC–FESA database toward fires documented by fire services in the metropolitan areas. Similarly, fires that occurred in the largest regional centres dominate the data reported for other regions. For example, 98 percent of fires within the Coral Coast region occurred in the Geraldton postcode. In the North West, fires were more evenly distributed across the postcodes that encompassed the major urban centres of Broome, South Hedland, Karratha, Mount Newman and with lesser numbers in the Derby and Carnarvon postcodes. Fires in the South West principally occurred in the postcodes encompassing Bunbury, Albany and to a lesser extent Collie. Fires in the Outback region mainly occurred around Kalgoorlie and in other areas in the southwest of the state.

It is important to reiterate that the AFAC–FESA data are incomplete and the above distribution cannot be considered representative of the distribution of vegetation fires across the state as a whole. Given reporting arrangements, data in urban areas covered by career fire fighters was more likely complete or near complete. Based on the AFAC–FESA and FESA data, a minimum of 54 percent of all vegetation fires documented occurred in the Perth region. Hence, the incompleteness of the data does not undermine the observation that an overwhelming majority of vegetation fires in Western Australia were associated with the greatest density of people. The strong association between larger fire numbers and larger regional centres would also support this observation. Both are consistent with the trends observed in other jurisdictions; that the greatest numbers of vegetation fires are attended in the region that encompasses the capital, and that the greatest numbers of vegetation fires in regional areas occur near the largest regional centres. While fire service data for Western Australia are likely to provide a broad guide to the distribution of vegetation fires generally, it is recognised that many of the vast numbers of fires that occur each year in tropical savannas, be they deliberately lit or naturally occurring, may not be attended.

High rates of deliberate fires were evident across all regions, ranging between 63 (South Coast) and 77 percent (Coral Coast) in those regions for which more than 300 vegetation fires were documented in the AFAC–FESA database for the 2000–01 to 2001–02 interval (Figure 19). Lower rates were documented for the North West and Outback regions, but both areas were characterised by lower reported fire numbers and higher proportions of fires of unknown causes.

Of the fires reported in the AFAC–FESA database, approximately 94 percent of non-deliberate child fires occurred in the Perth region, with a further two and one percent in the Coral Coast and South West regions, respectively. This parallels the distribution of fires across the state generally. Non-deliberate child fires accounted for 2.8 percent of all fires documented in the AFAC–FESA database for the Perth region, and between zero (North West) and 2.4 (Coral Coast) percent of fires in regional areas. These statistics are unlikely to be representative of children's involvement in starting fires in these regions because the AFAC–FESA data was incomplete and child fires were often included within the incendiary and suspicious categories.

The greatest number of smoking-related fires occurred in the Perth (n=1,497) and Coral Coast (n=63) regions, contributing to 12 and 19 percent of fires in these regions, respectively. In other non-metropolitan regions, smoking-related materials contributed to 2.1 to 3.6 percent of fires, akin to the values observed throughout Australia for non-metropolitan areas. The high proportions of smoking-related fires for the Coral Coast region may reflect the fact that 98 percent of fires in this region were within the Geraldton postcode, and that the incidence of smoking-related fires is commonly higher in urban areas than in non-urban (see below).

Perth region

This analysis examines the distribution and cause of fires included within the major metropolitan and Mandurah SSDs (Figure 20), excluding approximately 2.3 percent of fires that were listed as occurring in the Perth region but which were classified as belonging to other SSDs. It is reiterated that the SLAs and the SSDs) used in this analysis are not identical to those the ABS used, and some discordance exists between SSDs and tourism regions.

SSD: The largest numbers of vegetation fires (all causes) were documented in the North region, followed by South East and South West Metropolitan SSDs, with these SSDs accounting for 29, 27 and 22 percent of the fires documented for the Perth region (Figure 21). A further 13 percent of vegetation fires in this region occurred in the East Metropolitan SSD. Substantially lower numbers occurred in the Central Metropolitan (4%) and Mandurah (3%) SSDs.

High rates of deliberate fires were evident across all SSDs except the Central Metropolitan SSD, with rates ranging from 60 percent in the Mandurah SSD to 77 percent in the North Metropolitan region (Figure 21). In contrast, only 29 percent of vegetation fires in the Central Metropolitan SSD were classified as deliberate in origin.

The greatest number of smoking-related fires occurred in the South East, North and South West Metropolitan SSDs, accounting for 30, 21 and 21 percent of all smoking-related fires documented for the Perth region. Smoking-related materials were responsible for almost half of all fires in the Central Metropolitan area, but just 12 to 18 percent of fires in outlying SSDs (Figure 22).

SLA: The total number of vegetation fires varied markedly not only across the Perth region but also across individual SLAs within each SSD (Figure 23). The highest total numbers of fires within individual SLAs tended to occur in those SSDs that recorded the greatest numbers of fires overall, namely the North, South East and South West Metropolitan SSDs. In the South West Metropolitan SSD, the greatest number was documented for the Rockingham SLA, which experienced almost 1,400 vegetation fires in a two-year period. Similar levels were evident in the Canning SLA in the South East Metropolitan SSD. Although the North Metropolitan experienced the greatest number of vegetation fires overall, these tended to be more evenly distributed across SLA and postcodes in that region. Nevertheless, more than 900 vegetation fires were observed in two SLAs in the SSD in the two-year period (Joondalup–South and Stirling Central SLAs). All SLAs in the Central Metropolitan region were characterised by low numbers of vegetation fires.

In all outer metropolitan SSDs, the number and proportion of deliberate fires increased with increasing total numbers of fires (Figure 23), reflecting the fact that deliberate fires were the principal cause of increased fire numbers. The high percentage of deliberate fires documented for the North Metropolitan region as a whole was consistently observed at a local level, with rates of 70 to 80 percent being common across most SLAs in the SSD. In contrast to the outer metropolitan SSDs, the proportion of deliberate fires in the Central Metropolitan SSD tended to increase with decreasing numbers of fires per SLA. This reflected the higher numbers and proportions of accidental fires documented for the innermost areas of the city, namely within the Vincent and Perth–Remainder SLAs.

The greatest numbers of non-deliberate child fires were documented in the Rockingham, Canning, Melville, Armadale, Gosnells and Cockburn SLAs; areas that, overall, experienced high numbers of fires. Although statistically significant, there was only a moderate correlation between the number of non-deliberate child fires and the total number of fires in individual SLAs in the Perth region ($r=.75$, $p<.01$). The Rockingham, Canning and Melville SLAs accounted for 32, 18 and eight percent of all non-deliberate child fires in the Perth region. In these areas, non-deliberate child fires accounted for between five and eight percent of all fires in the SLA, higher than the average. The data were, however, incomplete and there were difficulties in ascertaining the distribution of child fires, owing to the incorporation of such fires in the incendiary and suspicious categories.

The number of smoking-related fires in a SLA was significantly positively correlated with the total number of fires in that SLA ($r=.87$, $p<.01$). That is, the greatest numbers of smoking-related fires tended to have been documented in those SLAs recording the greatest numbers of fires overall.

Postcode: The trends described at an SLA level were also demonstrated at a postcode level, albeit with greater variability at this more localised scale. When data were presented at a postcode level, it was clearly evident that a high proportion of all fires within a given SSD occurred within a comparatively small number of postcodes. For example, the eight postcodes each in the South East, seven postcodes in the North and four postcodes in the South West Metropolitan SSDs that recorded in excess of 200 vegetation fires (total) in two years were responsible for 66 to 83 percent of all fires in those SSDs (Table 2, Figure 24). In the South West the two suburbs recording in excess of 500 fires in two years were responsible for half the fires in the SSD. However, the concentration of fires varied between SSDs. For example, despite higher total numbers of fires than the South West Metropolitan SSD, only one postcode in the North Metropolitan SSD recoded in excess of 500 fires, accounting for just 14 percent of all vegetation fires in the SSD. This is consistent with the more dispersed nature of vegetation fires in this region, as outlined above. Nevertheless, even in areas that experienced low total fire numbers, like the Central Metropolitan region, fires tended to be concentrated in a small number of postcodes; 44 percent of fires in the Central Metropolitan region occurred in the two suburbs that recorded in excess of 100 fires in two years.

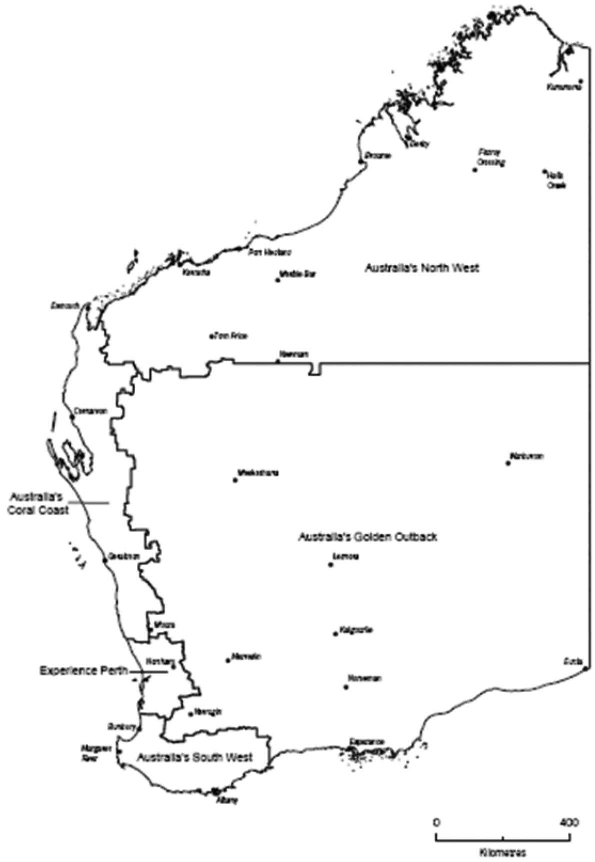
The trends described for vegetation fires overall were also evident within the deliberate fire data. In the North, South East and South West Metropolitan SSDs, the few suburbs recording in excess of 200 deliberate fires in two years, were responsible for between 53 and 70 percent of fires in those SSDs (Table 2, Figure 25). Postcodes with in excess of 100 deliberate fires were responsible for 83 to 86 percent of deliberate fires. In the South West one-fifth of all postcodes to record a fire of any cause were responsible for 86 percent of all deliberate fires (Figure 25). In the North and South East Metropolitan regions postcodes documenting in excess of 100 deliberate fires in two years, accounted for roughly 40 percent of suburbs to have experienced a fire. This concentration of fires within small areas enables targeted arson prevention strategies to be implemented within those areas.

Table 2: Number of postcodes with deliberate and total fire numbers within the specified ranges, and the extent to which they contributed to total fires numbers within each SSD

	North Metropolitan		South East		South West		East Metropolitan		Central Metropolitan	
	n	%	n	%	n	%	n	%	n	%
Total no of fires	3,586		3,359		2,693		1,645		515	
Total no. of postcodes	25		21		23		20		14	
TF>=500	1	14.2	2	30.1	2	49.2				
200–499	6	51.6	6	53.1	2	25.6	2	44.1		
100–199	5	21.2	1	3.3	1	7.4	4	35.2	2	43.5
75–99	2	4.9	2	5.6	1	3.2	1	5.9		
50–74	3	4.9	1	1.6	2	4.4	2	7.5	1	10.3
25–49	2	1.8	5	5.8	5	6.7	1	2.4	5	29.7
<25	6	1.4	4	0.6	10	3.5	10	4.9	6	16.5
Incendiary fires	24		20		21		16		14	
Total Incendiary	2,761		2,275		1,917		1,078		147	
>200	6	63.2	4	53.1	3	69.7	1	30.1		
100–199	4	20.1	4	32.2	2	16.1	3	38.1		
75–99	2	7.0					1	7.1		
50–74	1	2.6	3	8.2	1	2.8	2	13.1		
25–49	3	3.8	1	1.1	4	7.0	2	6.9		
<25	8	3.3	9	5.4	11	4.3	7	4.8	14	100.0

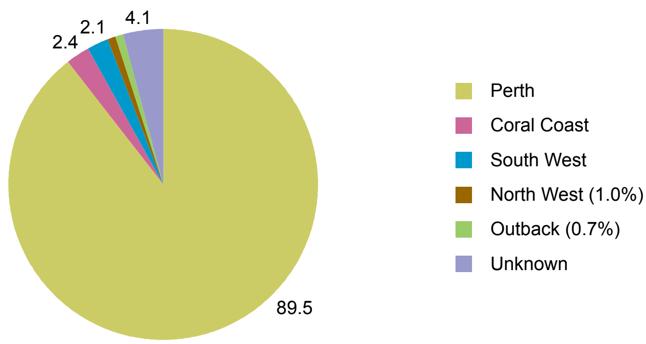
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 17: Tourism regions of Western Australia



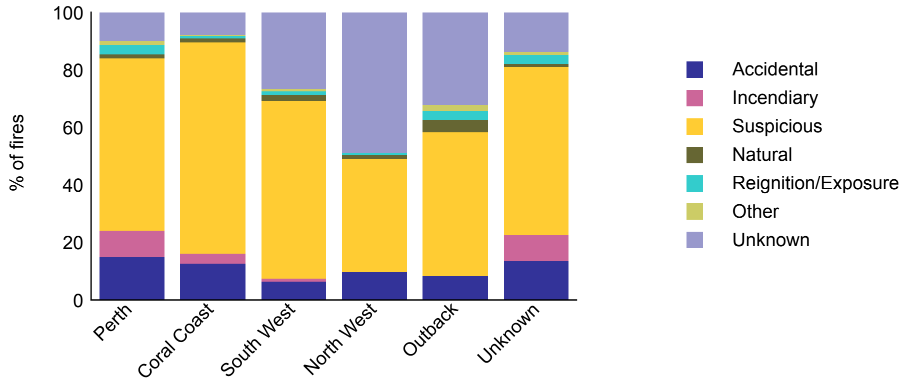
Source: ABS 2005b

Figure 18: Vegetation fires, by region, 2000–01 to 2001–02



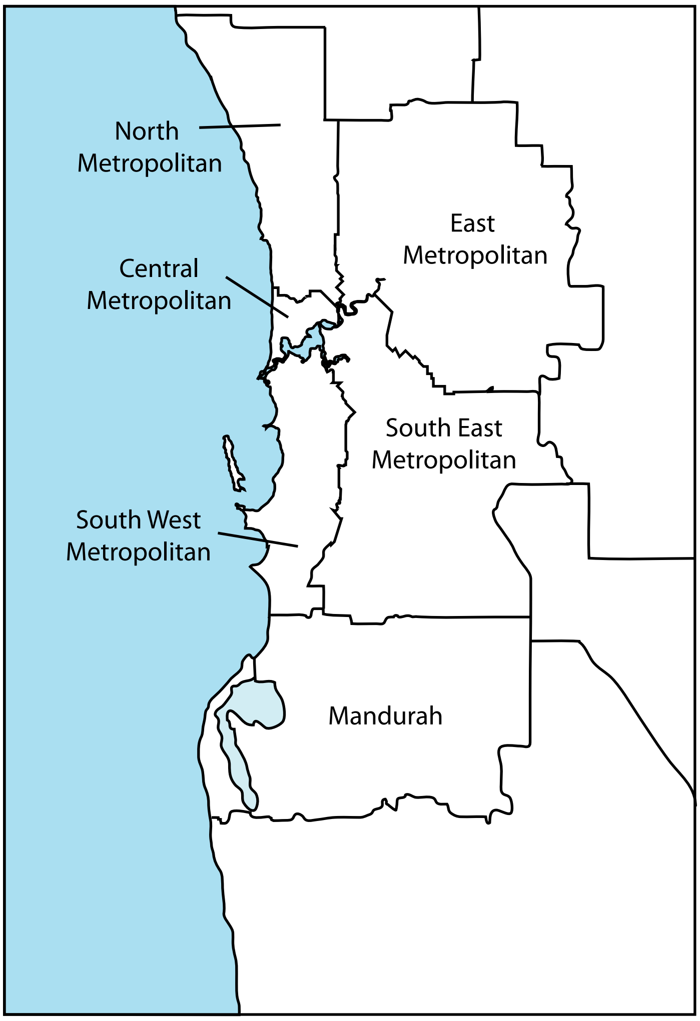
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 19: Cause of vegetation fires, by region, 2000–01 to 2001–02



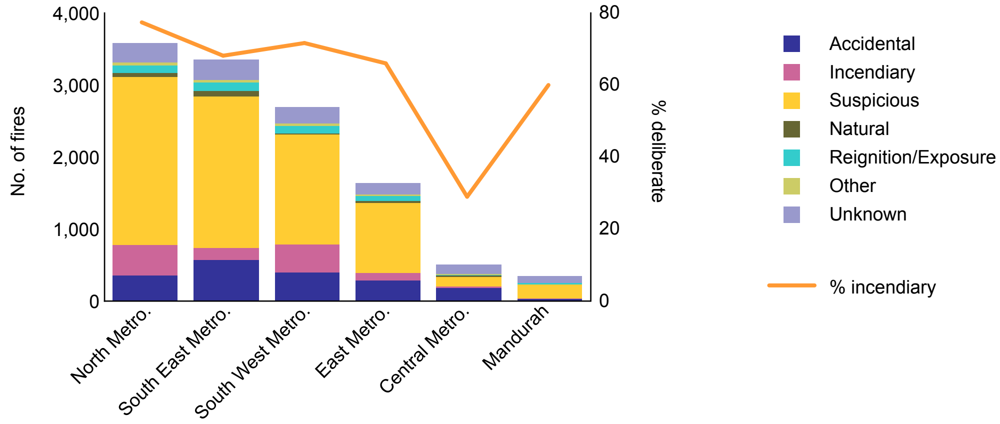
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 20: Map of SSDs in the Perth region



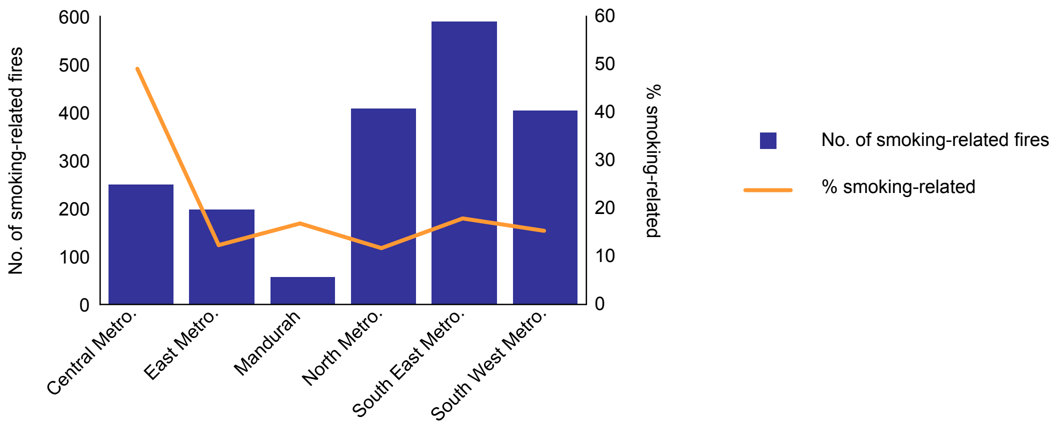
Source: ABS 2001a

Figure 21: Cause of vegetation fires in the Perth region, by SSD, 2000–01 to 2001–02



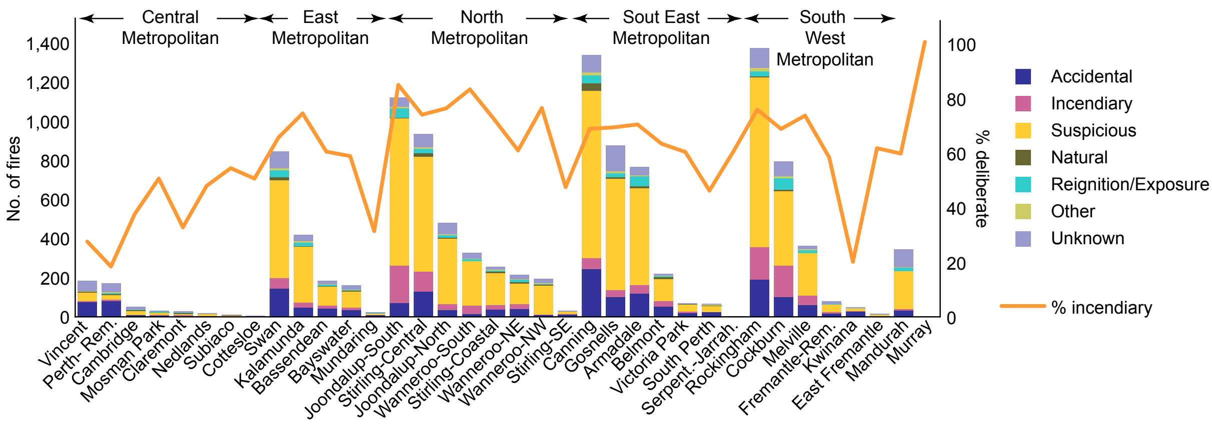
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 22: Smoking-related fires in the Perth region, by SSD, 2000–01 to 2001–02



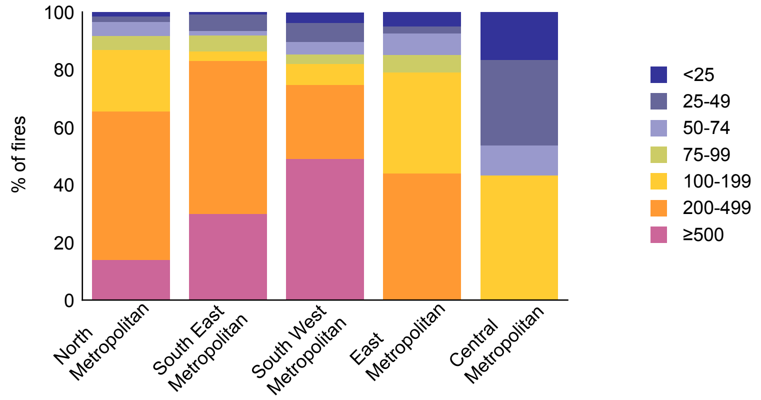
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 23: Cause of vegetation fires in the Perth region, by SLA, 2000–01 to 2001–02



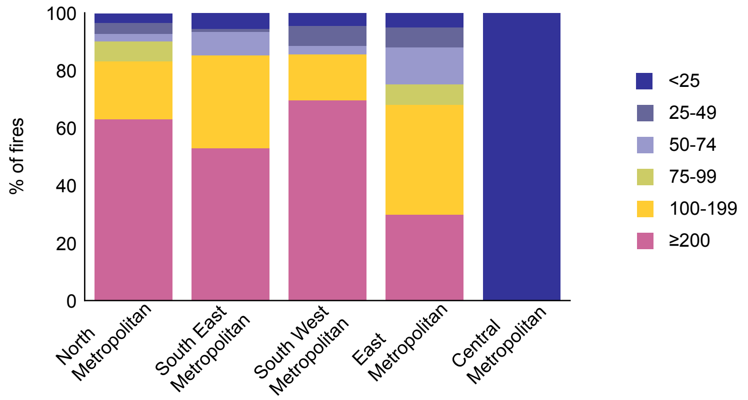
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 24: Perth region – distribution of fires within postcodes in each SSD (percent), 2000–01 to 2001–02



Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 25: Perth region – distribution of deliberate fires within postcodes in each SSD (percent), 2000–01 to 2001–02



Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Population

This section examines the relationship between frequency and causes of vegetation fires in relation to populations within individual postcodes. It is restricted to postcodes in the Perth region, as inclusion of incomplete data for postcodes in regional areas would have a profound impact on the rates of fires documented for postcodes with small populations.

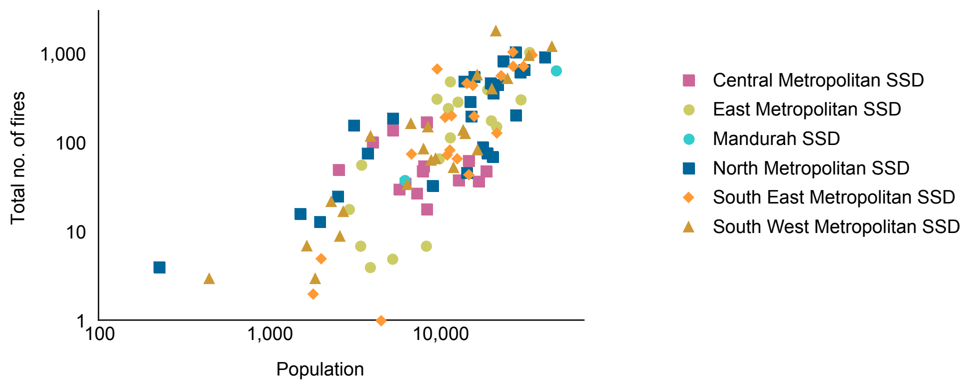
All vegetation fires: Overall, the total number of fires that occurred within individual postcodes increased as population of that postcode increased, consistent with the fact that people are the principle causes of vegetation fires (Figure 26). Individual postcodes in the Perth region commonly recorded between five and 200 fires per 10,000 people per year, although four postcodes – one each in the Kalamunda (East Metropolitan SSD), Stirling–Central (North Metropolitan SSD), Gosnells (South East Metropolitan SSD) and Rockingham (South West Metropolitan SSD) SLAs – recorded between 200 and 430 fires per 10,000 people per year (Figure 27). Consistent with the variability in absolute numbers of fires described above, a broad range of values was recorded in each SSD. Although postcodes with larger populations in the

Central Metropolitan SSD were characterised by low rates of fires on a per-person basis, postcodes with low populations were indistinguishable from other postcodes of the metropolitan area, having rates of fires of just over 100 fires per 10,000 people per year.

Deliberate vegetation fires: Individual postcodes in the Perth region were characterised by a broad range of deliberate fires on a per-person basis; typical values varied between one and 100 deliberate fires per 10,000 people per year, but two postcodes in the South East and South West Metropolitan SSDs recorded between 130 and 150 deliberate fire per 10,000 people per year (Figure 28). Overall, there was a tendency for the number of deliberate fires per person to increase with increasing population, although postcodes with similar populations tended to be characterised by high contrasting rates of fires, again highlighting that factors, other than population, affect the distribution of deliberate fires. Postcodes within the Central Metropolitan region were consistently characterised by low rates of deliberate fires on a per person basis, consistent with the low numbers of deliberate fires overall. Mandurah postcodes were also characterised by low rates of deliberately lit fires in comparison to similar-sized populations in other Perth postcodes.

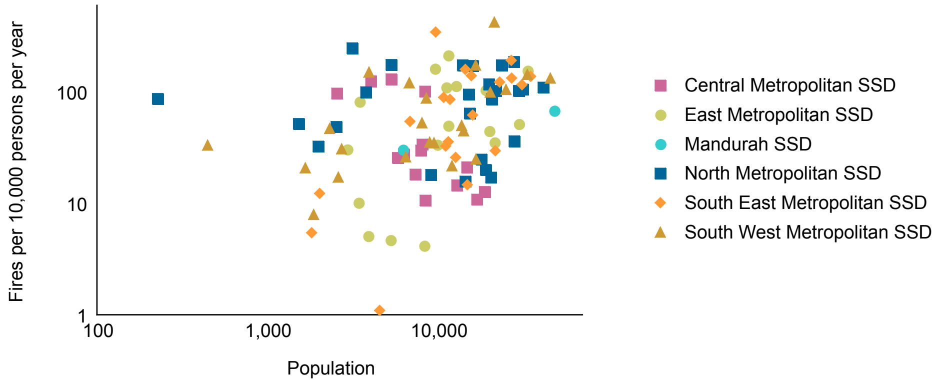
Smoking-related fires: Individual postcodes in the Perth region commonly experienced between one and 15 smoking-related fires per 10,000 people per year (Figure 29). Again, a broad range of values was observed in individual SSDs. This was most evident for the Central Metropolitan SSD, where between 20 and 70 smoking-related fires occurred in four postcodes that are overall characterised by low resident populations. It is highly probable that an increased incidence of smoking-related fires per person in this area was a result of higher migratory populations; large numbers of people visit inner city areas for work and social activities. On average, high rates of smoking-related fires were evident across the South East Metropolitan region. Although variable, comparatively lower rates were experienced in other metropolitan areas.

Figure 26: Vegetation fires and population, by postcode and SSD for the Perth region (number), 2000–01 to 2001–02



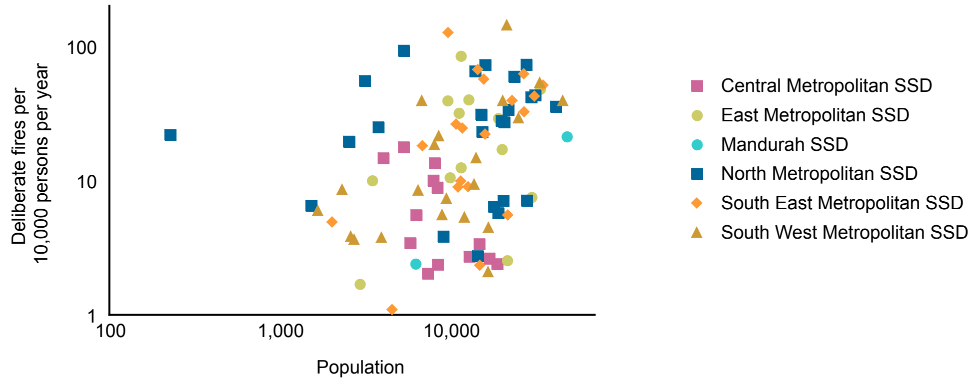
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]; ABS 2004. Population by post office area, 2001 [computer file]

Figure 27: Total number of fires per 10,000 people per year and population, by postcode and SSD for the Perth region (number), 2000–01 to 2001–02



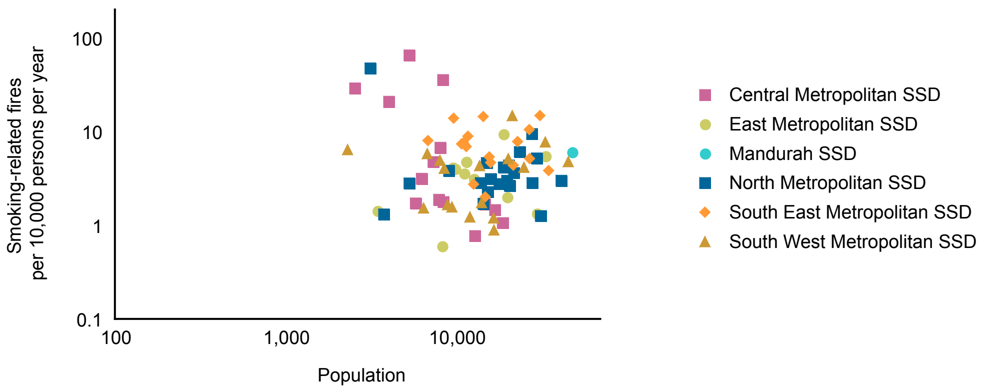
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]; ABS 2004. Population by post office area, 2001 [computer file]

Figure 28: Deliberate fires per 10,000 people per year and population, by postcode and SSD for the Perth region (number), 2000–01 to 2001–02



Source: FESA–AFAC 1997–98 to 2001–02 [computer file]; ABS 2004. Population by post office area, 2001 [computer file]

Figure 29: Smoking-related fires per 10,000 people per year and population, by postcode and SSD for the Perth region (number), 2000–01 to 2001–02



Source: FESA–AFAC 1997–98 to 2001–02 [computer file]; ABS 2004. Population by post office area, 2001 [computer file]

Complex

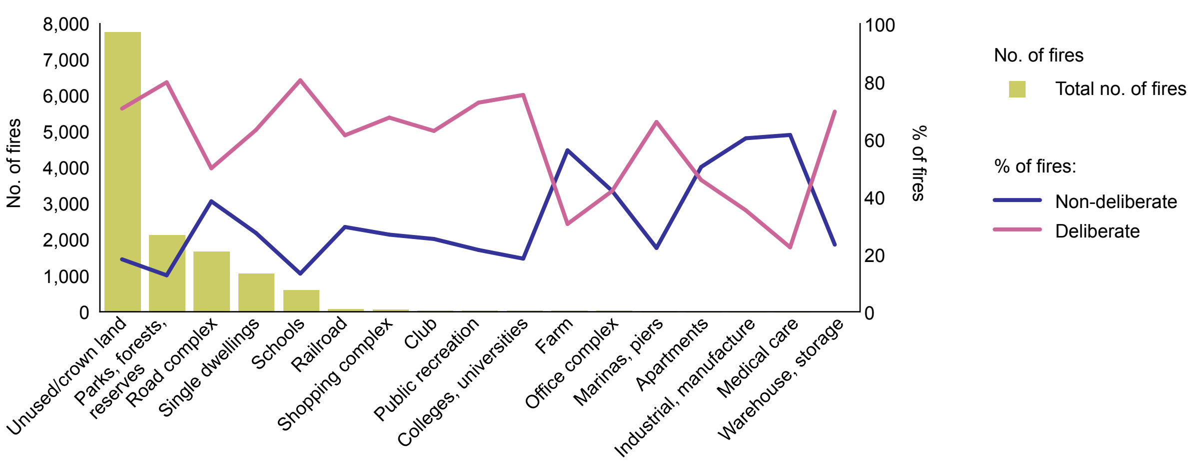
Fifty-six percent of all vegetation fires recorded in the AFAC–FESA database occurred on unused property or Crown land, with a further 40 percent occurring in parks and reserves, on roads, and around dwellings and schools (Figure 30).

The proportion of deliberate fires did not vary substantially between complex types where there was a high incidence of vegetation fires; 60 to 80 percent of fires were typically deliberately lit in these complex types. Nevertheless, subtle variations were evident. For example, the percentage of deliberate fires was lower for road complexes as a result of higher numbers of smoking-related fires. Conversely, a higher proportion of fires at schools, and parks, forests and reserves tended to be deliberate. The proportion of deliberate fires was more variable for more obscure locations (such as medical facilities) for which there were low fire frequencies.

Non-deliberate child fires also most commonly occurred on unused property or Crown land, followed by parks, forests and reserves, and single dwellings (Figure 31). The tendency for non-deliberate child fires to occur around dwellings decreased with increasing age. In contrast, there was a greater tendency for older children to light fires in parks, forests, and reserves. There was also clear evidence that the diversity of location where non-deliberate child fires occurred increased with age.

The majority of smoking-related fires also occurred on unused property or Crown land, but this cause comprised a small proportion of all fires that occurred at that complex type (Figure 32). Road complexes were the other principal location where smoking-related fires occurred, with smoking-related materials; 35 percent of all fires that occurred at road complexes were classified as smoking-related. There appears to be a very strong correlation between mulch used in streetscape beautification and bush fires caused by discarded material (such as cigarettes). The cause of these fires can be determined with some certainty, as the cigarette butt will remain after igniting the mulch. This residue characteristic is not present with either grass or native bush fire ignition. Not surprising, smoking-related causes also accounted for a comparatively high proportion of vegetation fires for locations like office complexes (33.3%; n=12), medical and care facilities, motels, apartments and restaurants, locations where large numbers of people, most routinely concentrate to smoke. However, overall such locations contributed a comparatively small number of smoking-related vegetation fires, possibly because these locations also tended to be equipped with adequate cigarette disposal facilities.

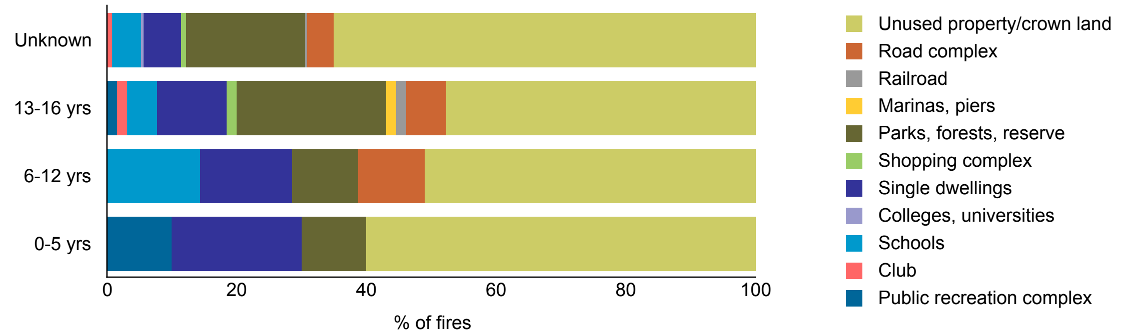
Figure 30: Number and cause of vegetation fires, by complex, 2000–01 to 2001–02



Note: Only includes locations where 10 or more incidents were recorded in two years

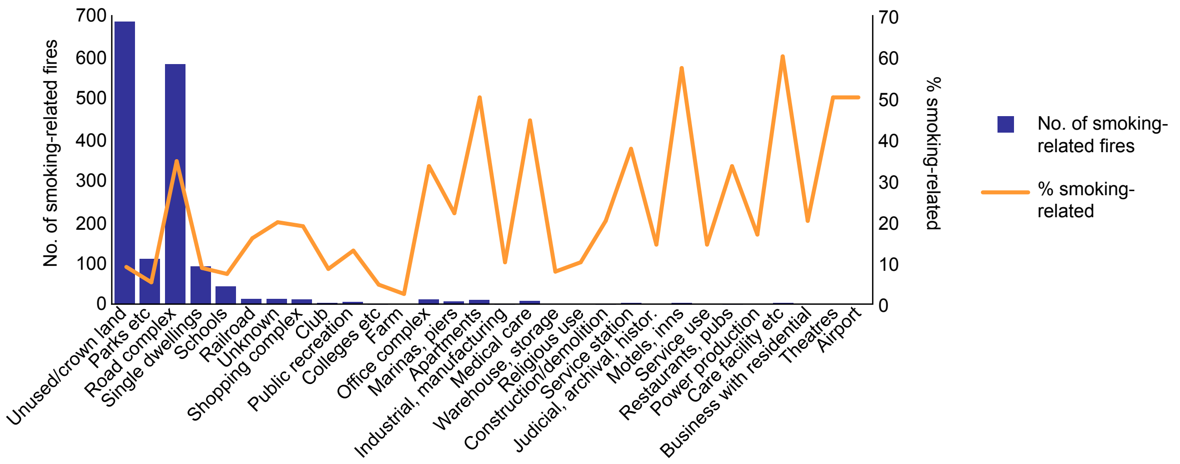
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 31: Non-deliberate child fires, by complex (percent), 2000–01 to 2001–02



Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 32: Smoking-related fires, by complex, 2000–01 to 2001–02



Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Timing

The timing of fires was examined by week of the year, day of the week, and by time of the day. The analysis for fires by week of the year is based on the AFAC–FESA database for the period spanning 1997–98 to 2001–02, unless otherwise noted. Hence, this analysis uses vegetation fires defined using the alternative definition of wildfires. In contrast, the analysis of fires by day of the week and time of day only used data from the 2000–01 to 2001–02 interval, where vegetation fires were defined using the AIRS wildfire definition.

Week of the year

As noted in the introduction, due to significant latitudinal variations in climate Western Australia can potentially experience bushfires in any month of year. Consistent with fire regimes, most vegetation fires in the South West and Perth regions occurred during spring and summer, whereas peak numbers in the North West region occurred between June and November (Figure 33). As most fires within the AFAC–FESA database were located in southern Western Australia, there was overall dominance toward spring–summer fires in the analysed data. Nevertheless, subtle differences were evident between regions in the southern half of the state. Fire frequencies on the Coral Coast in the Outback peaked largely within a narrow interval from mid October to mid January and mid December respectively. A similar peak in activity was evident for the Perth region, although high numbers in that region remained until late April (Figure 34).

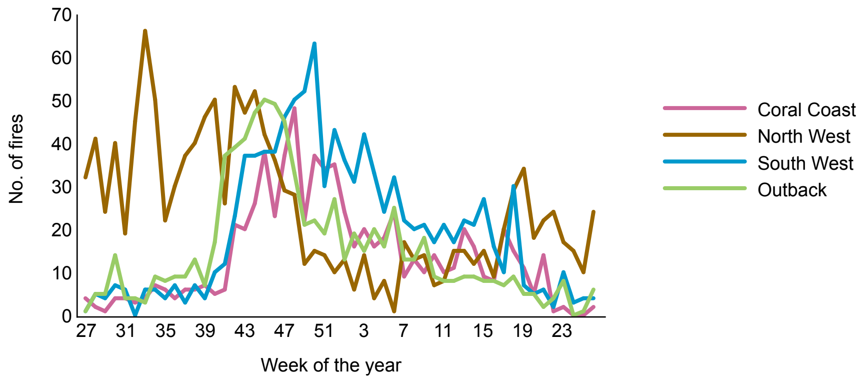
Systematically higher weekly average fire numbers were observed in the latter portion of the calendar year relative to the beginning of the following calendar year in virtually all SLAs in the Perth region (Figure 35). This trend was also observed for the Coral Coast and South West regions. There is no obvious evidence to suggest that the fire danger is any different during the November–December period as compared to January–February.

Overall, the timing of the bushfire season was remarkably uniform across years (Figure 36), with the greatest variability occurring between week 6 (mid February) and week 15 (mid April). This is consistent with climatic variations observed for southern Western Australia. The rapid increase in fire frequency in the Perth region during October accompanied the equally rapid decline in rainfall in that month, which occurs consistently each year. In contrast, rainfall in January–March is more variable, contributing to the more variable fire frequencies during that time (Figure 37).

There was strong correspondence between the timing of deliberate and non-deliberate fires in a given year. Peak numbers of natural fires occurred from the beginning of December through to the end of February.

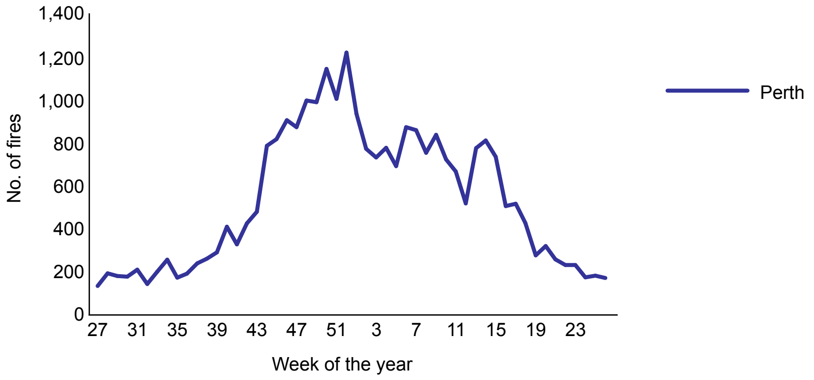
Fires lit by 6 to 12 year olds and 13 to 16 year olds principally, but not exclusively, coincided with the bushfire season (Figure 38). Whether this reflected an increased awareness of the susceptibility of the environment to fire, or increased mobility in the environment during the summer months is unclear. A large spike in non-deliberate fires lit by 13 to 16 year olds occurred in week 10 and week 45, in the middle of the first and last school terms respectively (based on 2000–01 to 2001–02 data only).

Figure 33: All vegetation fires, by region and week of the year (number), 1997–98 to 2001–02



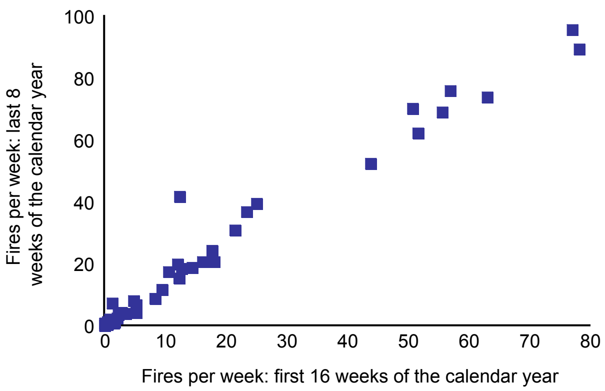
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 34: All vegetation fires in the Perth region by week of the year (number), 1997–98 to 2001–02



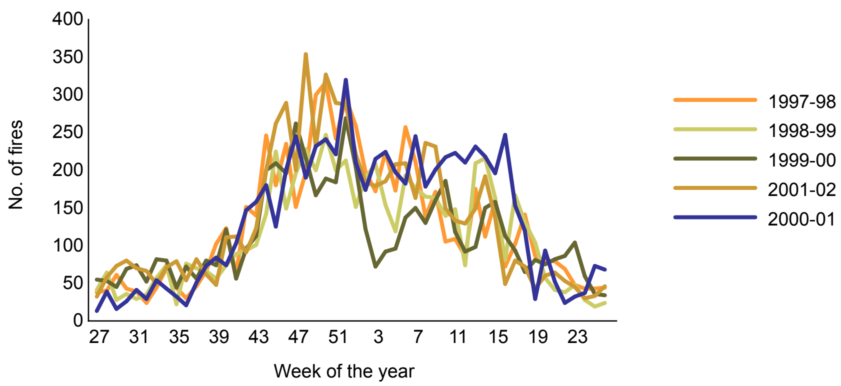
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 35: Fire frequencies at the end and beginning of the calendar year (number), by Perth SLA, 1997–98 to 2001–02



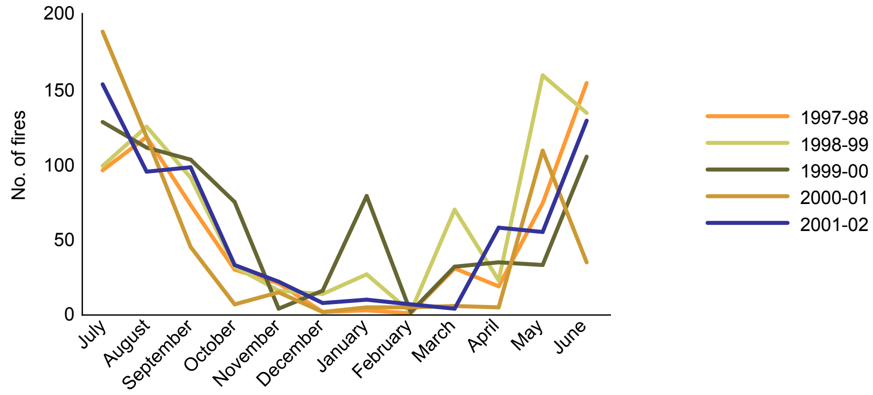
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 36: All vegetation fires, by week of the year and year (number), 1997–98 to 2001–02



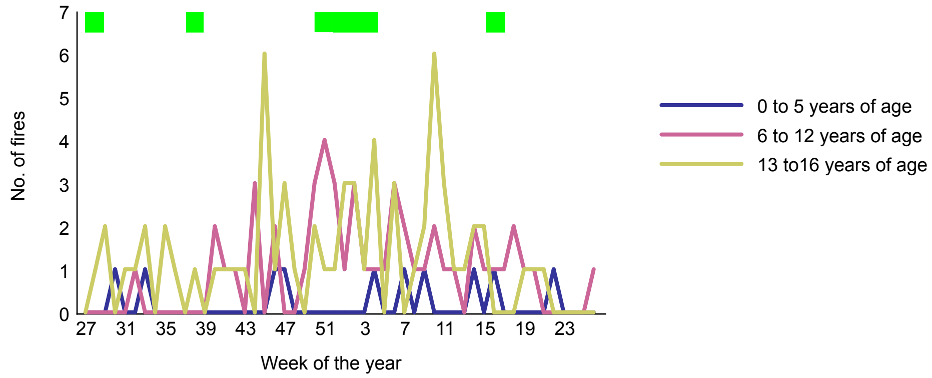
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 37: Central Coast region, district average rainfall (number), 1997–98 to 2001–02



Source: Australian Bureau of Meteorology [computer file]

Figure 38: Non-deliberate child fires, by week of the year (number), 2000–01 to 2001–02



Note: green blocks indicate the typical timing of school holidays
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Day of the week

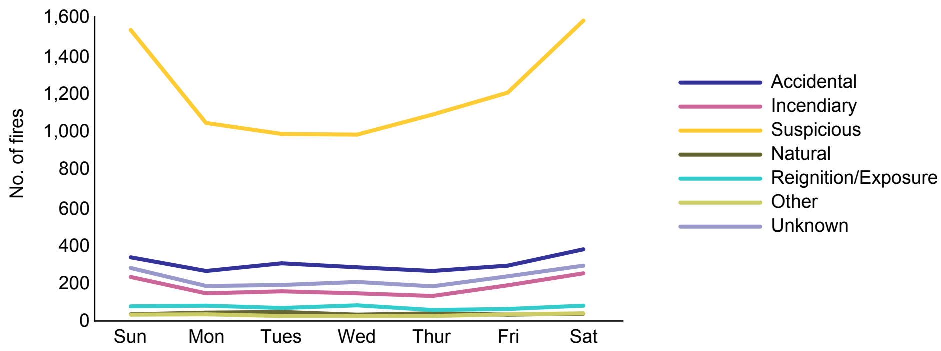
A considerably higher proportion of vegetation fires occurred on Saturdays and Sundays relative to weekdays. Notably, 47 percent more fires occurred on Saturday and 39 percent more fires occurred on Sunday than the weekday average for 2000–01 and 2001–02. This trend was evident for both accidental and deliberate fires (Figure 39). Forty-six percent more deliberate fires occurred on Sunday, and 52 percent more deliberate fires occurred on Saturday relative to the weekday average. In contrast, 21 percent more accidental fires occurred on Sunday and 36 percent more accidental fires occurred on Sunday relative to the weekday average.

Based on the available data, it appears that the increase in the number of vegetation fires on weekend days was not uniformly manifest across the state. The proportion of fires on weekends was greatest for the Perth region, with a slightly greater incidence occurring on Saturday (46%) relative to Sunday (41%; Figure 40). Increased fire frequencies occurred on both Saturdays and Sundays in the Southwest, but only on Saturdays for the North West and Outback regions (Figure 41).

Not surprising, given that a higher proportion of deliberate fires were lit on weekends and that a higher proportion of deliberate fires related to use of an open flame than to non-deliberate fires, there was an increase in the number of fires resulting from open flames on Saturdays and Sundays (50 to 55% increase). In contrast, the incidence of smoking-related fires was 26 percent higher on Saturday, but no more likely on Sunday compared to the weekday average.

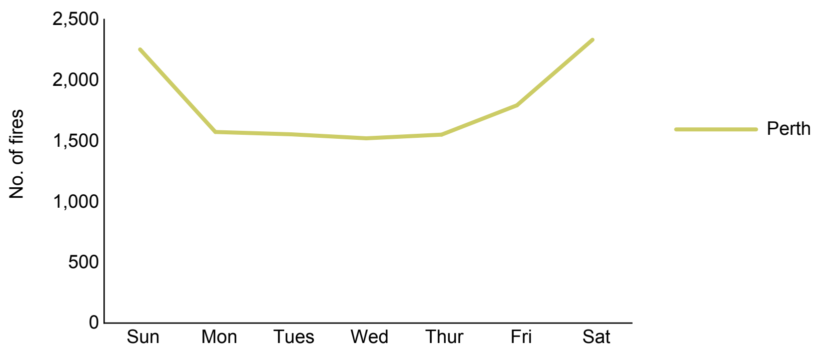
Non-deliberate child fires were 58 percent higher on both Saturday and Sunday relative to the weekday average (based on 2000–01 to 2001–02 data only). This increase was most pronounced for the 13 to 16 year old age group (Figure 42).

Figure 39: Cause of fires, by day of the week (number), 2000–01 to 2001–02



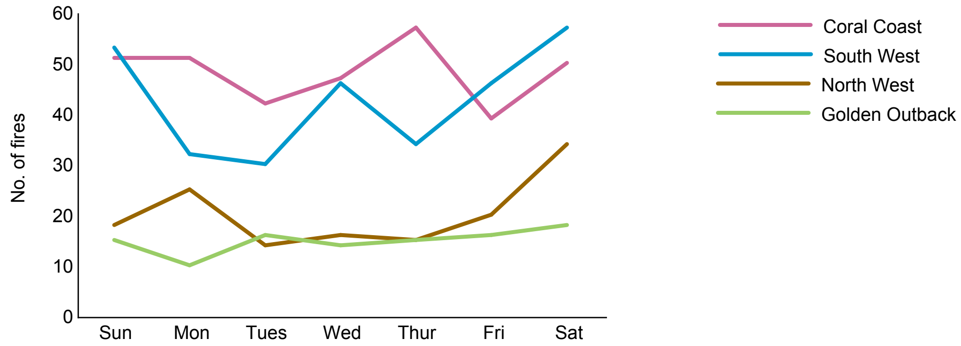
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 40: All vegetation fires, by day of the week for the Perth region (number), 2000–01 to 2001–02



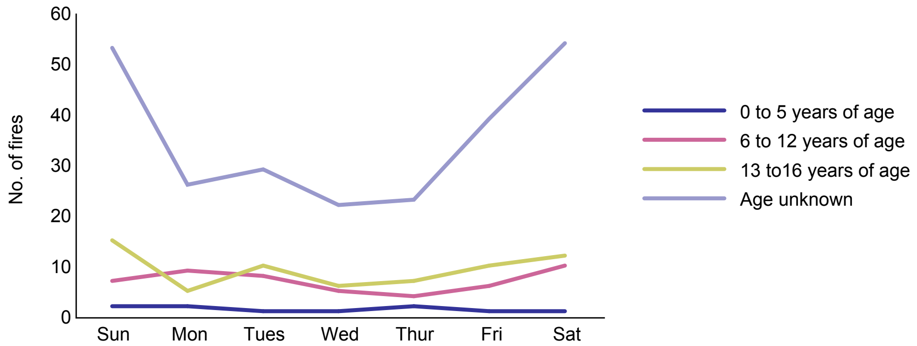
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 41: All vegetation fires, by day of the week for selected regions (number), 2000–01 to 2001–02



Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 42: Non-deliberate child fires, by day of the week and child age (number), 2000–01 to 2001–02



Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Time of day

The time of day was based on the time the alarm was raised. Although it does not provide an exact time the fire started, it does serve as a useful guide, particularly given that delay between ignition and detection, and subsequent alerting of authorities is likely to be comparatively short in urban areas. Detection times were only available for 61 percent of fires in the AFAC–FESA database, for 2000–01 and 2001–02.

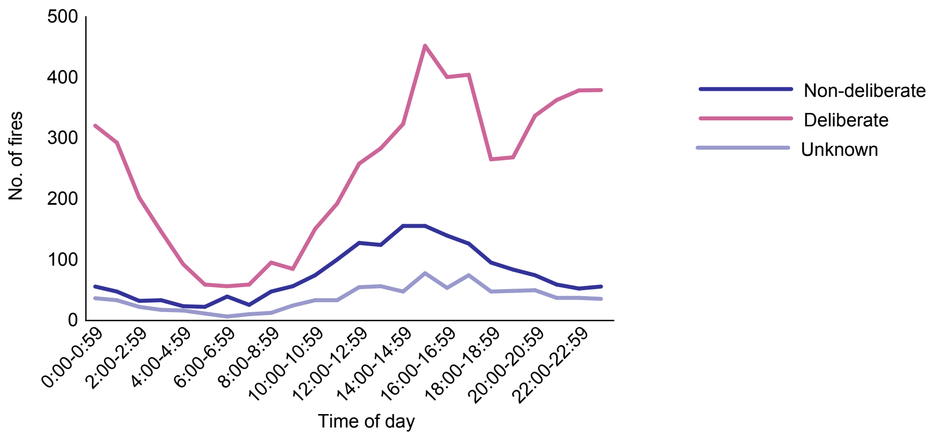
Clearly divergent trends were evident for non-deliberate and deliberate fires (Figure 43). The number of non-deliberate fires increased from 8 am onwards, peaked at between 2 and 3 pm and then declined through the remainder of the day and into the early hours of the following morning. In contrast deliberate fires defined a bimodal distribution. One peak coincided with non-deliberate fires. Nevertheless, in contrast to non-deliberate fires the daytime peak for deliberate fires has an asymmetrical distribution, with peak numbers of fires occurring between 3 and 4 pm, coincident with the end of the school day. After 7 pm the number of deliberate lightings increased markedly, thereby defining a second peak with a maximum around midnight. Deliberate fire frequencies subsequently declined to a minimum at 5 to 7 am the following morning.

Deliberate fires at night were observed across all regions, but most strongly manifested (based on available data) in the Perth (Figure 44) and South West (Figure 45) regions. One-half of all deliberate fires in these areas occurred between 7 pm and 6 am with 19 percent occurring between midnight and 6 am. In comparison, 35 to 37 percent of deliberate fires the North West and Golden Outback regions occurred between 7 pm and 6 am, with 13 and 20 percent being between midnight and 6 am in these regions respectively. The available data for the Coral region indicates one-quarter of deliberate fires occurred between 7 pm and 6 am with just six percent occurring between midnight and 6 am. Similarly, deliberate fires at night were a feature of all SLAs within the Perth region where total numbers of deliberate fires exceeded 20 in two years (Figure 46). A high proportion of deliberate fires occurred at night in the Joondalup–South, Kalamunda and Stirling–Coastal SLAs. In contrast, a smaller proportion of deliberate fires occurred at night in the Rockingham, Joondalup–North and Mandurah SLAs.

Although deliberate fires occurred after 7 pm and before 6 am on all nights of the week (timing may vary at a local scale) by far the greatest number occurred on Friday night–Saturday morning and Saturday night–Sunday morning (Figure 47). Notably, 48 percent of all deliberate fires in the Perth region that occurred between 7 pm and 6 am occurred on Friday night–Saturday morning and Saturday night–Sunday morning. These fires accounted for almost one-quarter of all deliberate fires in the Perth region, where the time of fire was documented. Fifty-nine percent of all deliberate fires documented in the AFAC–FESA database to have occurred between 12 am and 6 am also occurred on Friday night–Saturday morning and Saturday night–Sunday morning. Deliberate fires at this time accounted for 11 percent of all deliberate fires in the Perth region, where the time of the fire was documented. These trends indicate a strong relationship between social activities and deliberate fire ignitions, with many possibly being associated with drug and/or alcohol use.

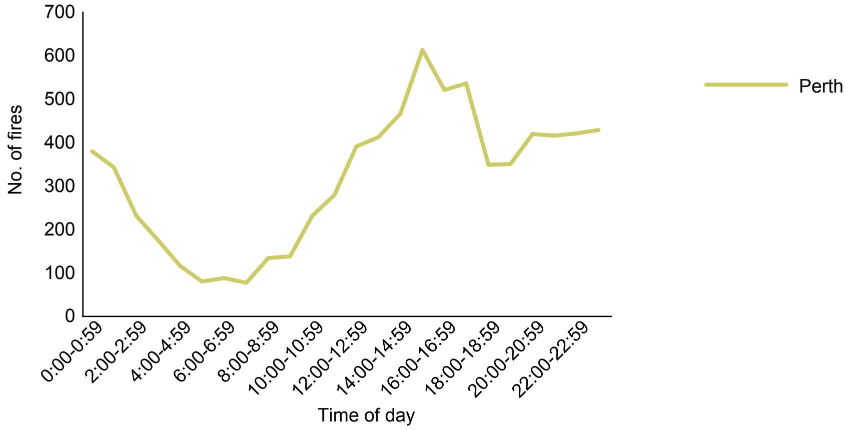
The time of day was available for 65 percent of non-deliberate child fires. The majority (70%) occurred between 8 am and 8 pm (Figure 48). Slight differences were evident between age groups. Fires attributed to children less than five years of age occurred within the interval between midday and 7 pm whereas older groups were observed throughout the day. Although based on a small sample, it was evident that the greater proportion of fires that occurred outside the 8 am and 8 pm interval increased with age from zero for less than 5 year olds to 13 percent for 6 to 12 year olds and 24 percent for 13 to 16 year olds. However, peak times for both the 6 to 12 and 13 to 16 year age groups were between 3 and 4 pm, coincident with the end of the school day.

Figure 43: Time of day, by cause (number), 2000–01 to 2001–02



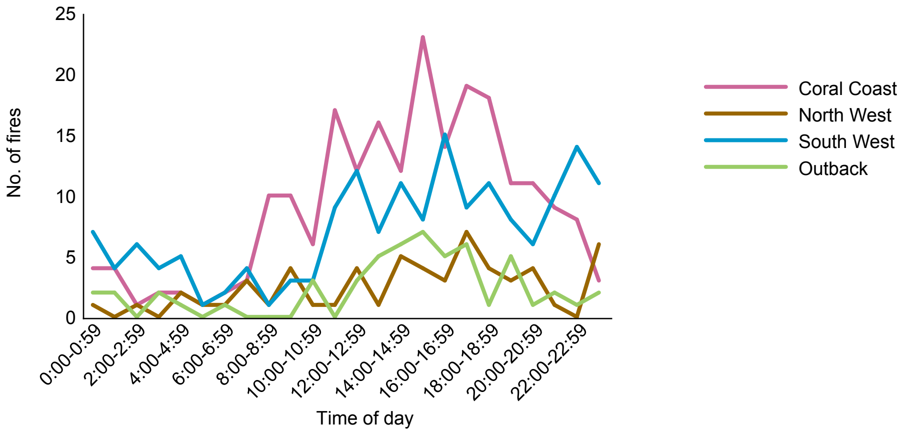
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 44: Time of day for all vegetation fires in the Perth region (number), 2000–01 to 2001–02



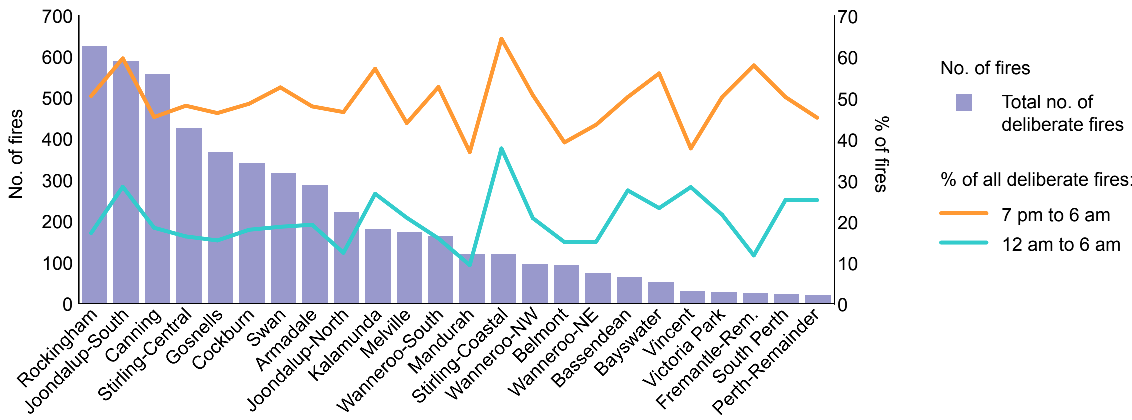
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 45: Time of day for all vegetation fires in other regions (number), 2000–01 to 2001–02



Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

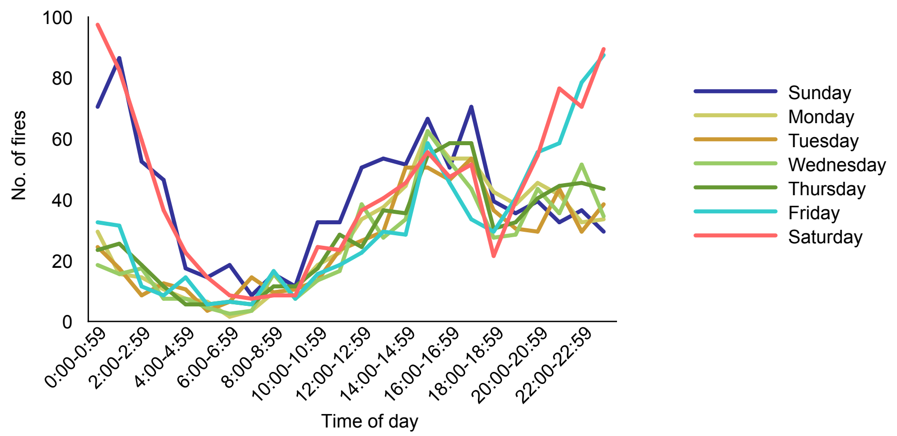
Figure 46: Deliberate fires at night[a], by Perth SLA, 2000–01 to 2001–02



a: the number of deliberate fires only refers to the number of deliberate fires for which the detection time was known; only includes SLAs were there were more than 20 deliberate fires in two years where the time was known

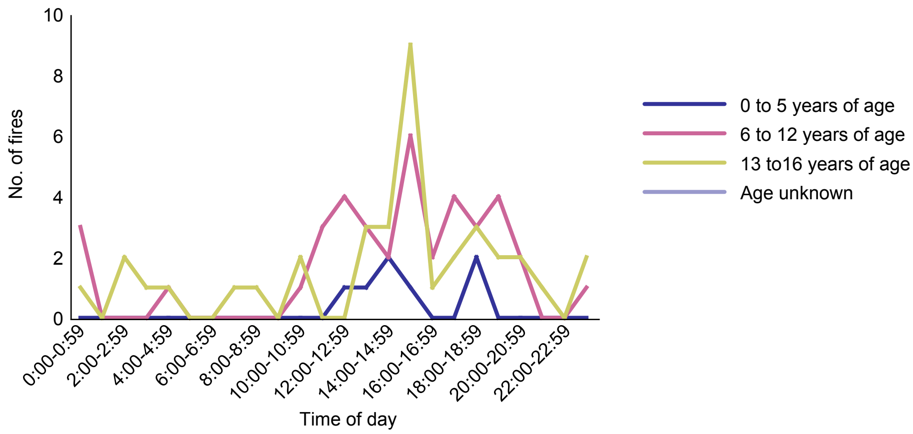
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 47: Time of day for deliberate fires in the Perth region, by day of the week (number), 2000–01 to 2001–02



Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 48: Non-deliberate child fires, by time of day and child's age (number), 2000–01 to 2001–02



Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Fire danger

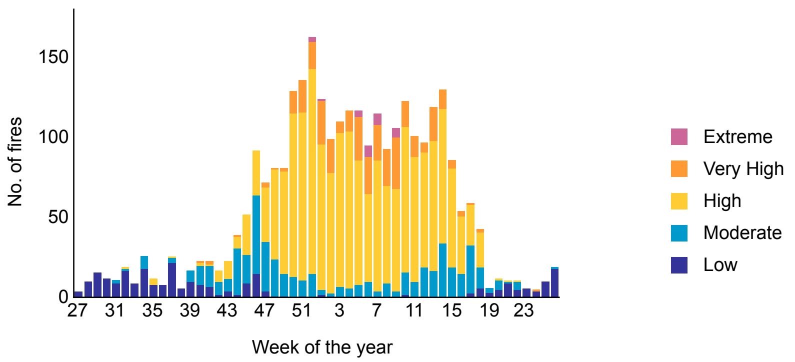
Information about fire danger rating was only available for 22 percent of cases for 2000–01 and 2001–02, with 'not applicable' attributions having been made in 76 percent of cases in the AFAC–FESA database. The distribution of data covers the entire year. As both deliberate and non-deliberate fires primarily occurred during the bushfire danger season, a high proportion of fires fell within periods of high fire danger (Figure 49). Overall, fires occurring under high fire danger conditions (62% of known) outweighed those occurring during moderate (17% of known) and very high danger (11% of known). Only nine percent of instances where the fire danger rating was assigned occurred under low fire danger conditions. Only one percent occurred under extreme fire conditions.

This general distribution was evident irrespective of whether the cause of the fire was deliberate or non-deliberate (Figure 50), indicating that the distribution is largely governed by distribution of fire danger rating over the bushfire season. However, the proportion of deliberate fires decreased with increasing fire danger, commensurate with an increased proportion of accidental and natural fires (Figure 51); there was a 2.5 and five times increase in the proportion of accidental and natural fires under extreme, as opposed to moderate, fire danger rating conditions.

Of interest, is whether there is a tendency for deliberate fires to occur during periods of fire restrictions or total fire bans (TFBs). A far greater body of information was available about the status of fire restrictions and TFBs than for fire danger, but there was not a one-to-one relationship between the two within the available data. A broad range of restriction/TFB status was reported for each fire danger category. As would be expected the proportion of TFB fires increased with increasing bushfire danger (Figure 52). Three-quarters of the fires in Western Australia took place when no fire restrictions or bans were in place (Figure 53).

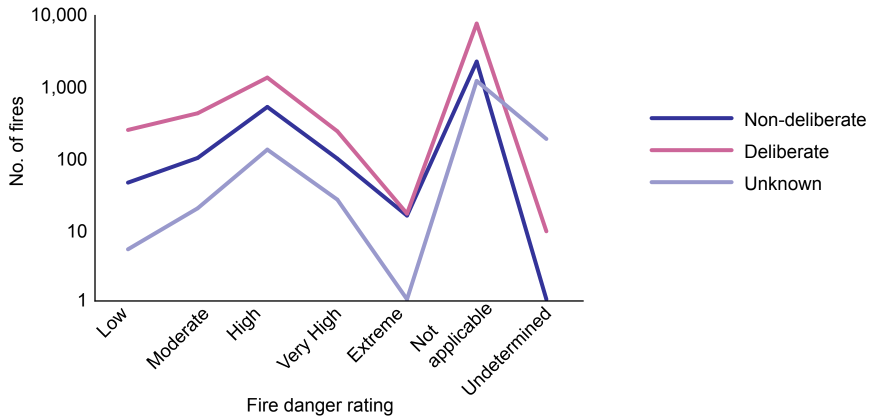
There was a broad relationship between general fire frequency and incidences of vegetation fires under a TFB. Overall, the number of fires lit during a TFB within a particular postcode increased with total fire frequency (Figure 54), such that one-quarter of all fires that occurred during a TFB were in the five postcodes that recorded more than 500 fires in a two-year interval (Figure 55). Almost 80 percent of fires lit during a TFB occurred in the 24 postcodes that recorded 100 or more fires per year. Between 40 and 50 percent of postcodes recording in excess of 200 fires in two years also recorded more than 10 percent of fires lit during a TFB (Figure 56).

Figure 49: All vegetation fires, by bushfire danger rating (number), 2000–01 to 2001–02



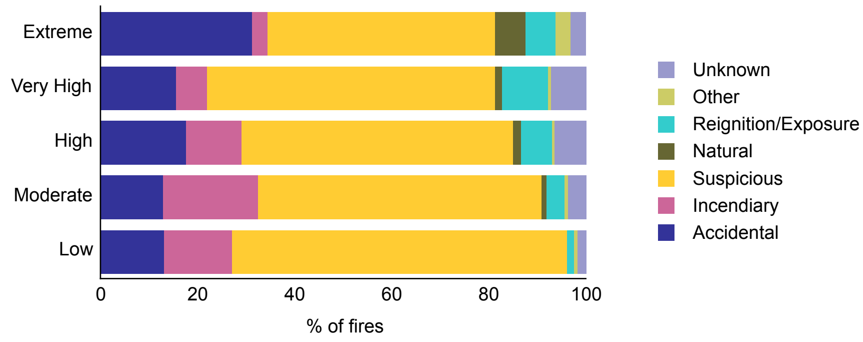
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 50: Fire danger index, by cause (number), 2000–01 to 2001–02



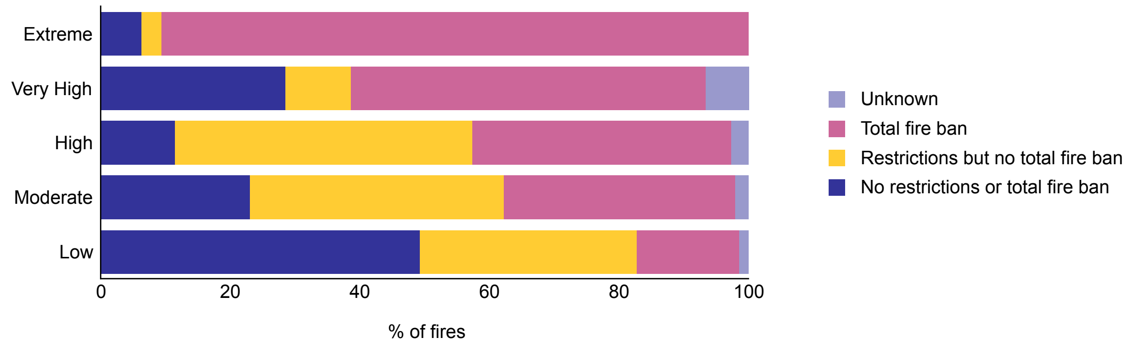
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 51: Fire danger index, by cause (percent), 2000–01 to 2001–02



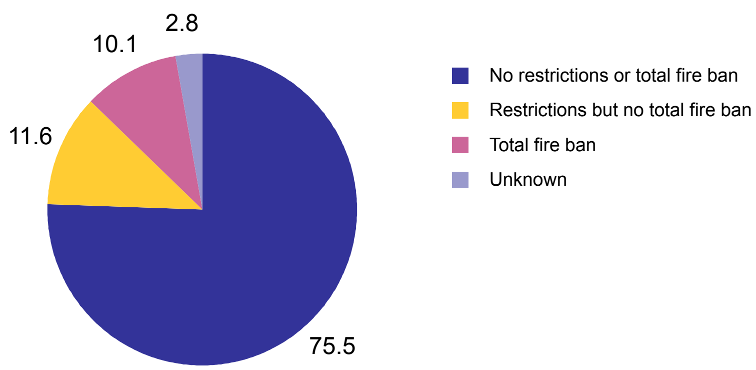
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 52: Fire restrictions and bans, by fire danger (percent), 2000–01 to 2001–02



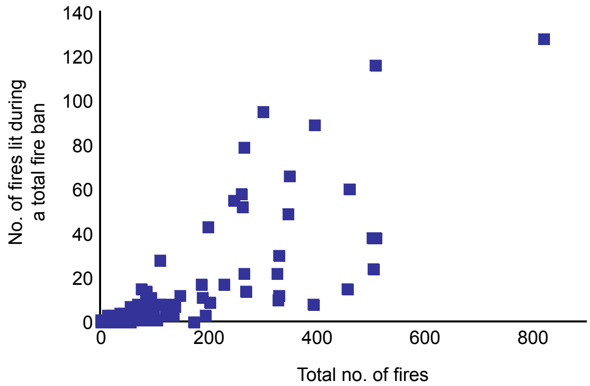
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 53: Fire restrictions and bans (percent), 2000–01 to 2001–02



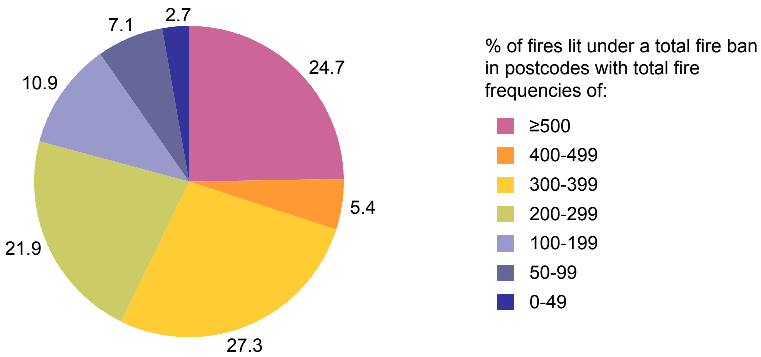
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 54: Fires lit during a TFB and total fires, by postcode (number), 2000–01 to 2001–02



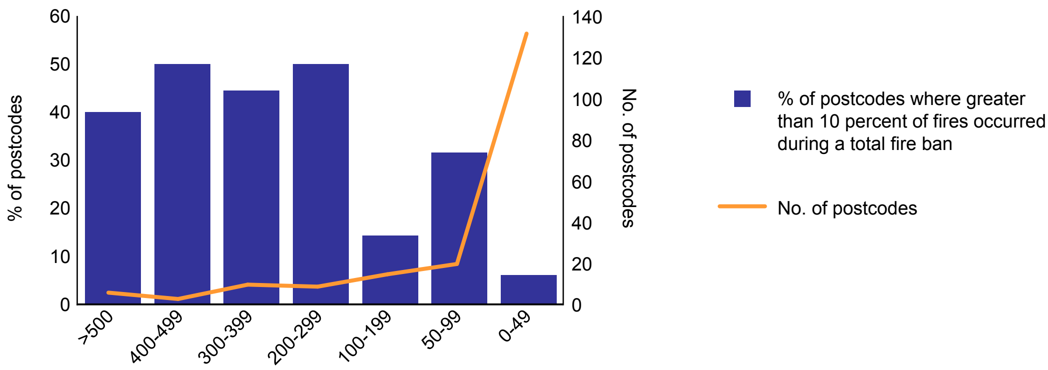
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 55: Fires lit during a TFB, by total number of fires recorded in a postcode in two years (percent), 2000–01 to 2001–02



Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Figure 56: Percentage of postcodes recording in excess of 10 percent of fires during a TFB, arranged by decreasing total fire frequency, 2000–01 to 2001–02

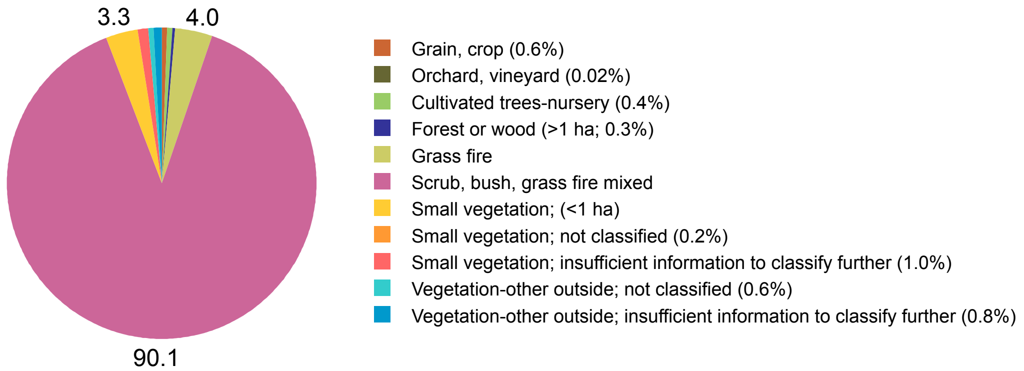


Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

Type of incident

The type of incident attended was 'all vegetation fires documented by FESA for the interval 2000–01 to 2006–07 (supplementary data supplied by FESA). Of these, 94 percent were documented as scrub or bush and grass mixtures, 3.5 percent were small vegetation fires (principally less than one hectare), and 1.3 percent were grassfires (Figure 57). Only 0.2 percent of fires were forest or wood fires (greater than one hectare).

Figure 57: Type of incident (percent), 2000–01 to 2006–07

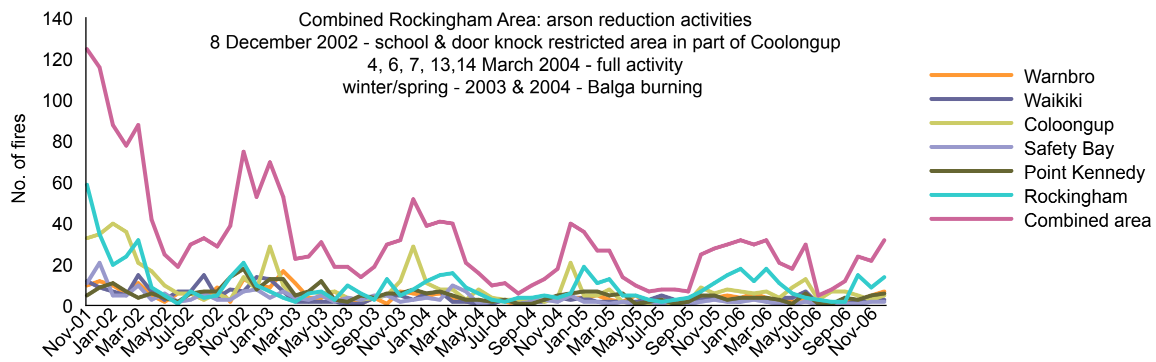


Source: FESA 2000–01 to 2006–07 [computer file]

Factors impacting on FESA fire frequencies

Concurrent with, and subsequent to, this analysis FESA introduced a number of initiatives that virtually halved the total number of vegetation fires occurring in Western Australia each year, with numbers dropping from almost 11780 fires in 2000–01 to 6529 fires in 2005–06. These initiatives included targeted arson reduction measures, such as school visits, door knocks and shopping centre displays. Other measures were taken to manage fuel loads in key areas during critical periods and implement strategies to reduce the likelihood of smoking-related fires in urban streetscapes. The impact of such programs at a local level is demonstrated in Figure 58.

Figure 58: Number of fires monthly in selected areas, individually and combined, before and after introduction of targeted arson reduction measures



Source: FESA [computer file]

Western Australian Department of the Environment and Conservation

Background about the WADEC dataset and its analysis

Important details about the Western Australian Department of the Environment and Conservation (WADEC) data analysis are summarised below:

- The data were sourced from WADEC.
- The dataset provided included only vegetation fires for the period 1999–2000 to 2002–03.
- The database does not use AIRS codes.
- The cause of fires was defined based on the 'Fire cause description' variable.
- Within the 'Fire cause description' variable, WADEC defined a causal category titled deliberate. In order to maintain consistency across agencies, these fires are titled incendiary within the seven-fold causal classification scheme (that is, accidental, incendiary, suspicious, natural, etc.) and as deliberate in the non-deliberate versus deliberate classification schemes adopted in this analysis. In addition, fires where the cause was listed as 'unknown' or 'cause not listed' but for which an offence was suspected, in the 'Offence suspected' variable, were classified as suspicious within the seven-fold causal category variable and as deliberate within the non-deliberate versus deliberate classification scheme.
- Natural vegetation fires were exclusively the result of lightning.
- Information about form of heat of ignition was supplied.
- The regions used in the WADEC analysis were provided by WADEC and differ from the regions used in the FESA analysis. WADEC further subdivides regions into divisions.
- The database included area burned.
- Information was available about fire restrictions or fire danger index but was in a numerical format, and was not used.
- Detailed information was available about the type of vegetation burned, and the tenure of lands on which fires occurred.

For more detail about these methodologies see the methodology chapter.

Overview

Fires WADEC attended can be summarised as:

- WADEC recorded 2,511 vegetation fires in the years 1999–2000 to 2002–03. Overall, the number of fires attended in any one year was comparatively uniform, ranging from 545 in 1999–2000 to 706 in 2000–01 (Figure 59).
- Of these, 25 percent were in national parks, nature reserves and other WADEC reserves, 44 percent were in state forests, 17 percent were on private property and 13 percent were on other Crown lands.
- Just over half (54%) the fires were deliberately lit (42% incendiary; 12% suspicious), with deliberate causes accounting for 60 percent of assigned causes.
- Three-quarters of vegetation fires occurred in the Swan (Perth) or South West regions of Western Australia.
- Collectively 4,876,416 ha were burned in WADEC fires, with incendiary and suspicious fires being responsible for 6.7 percent of the total area burned.

Cause

Incendiary and suspicious fires accounted for 41.9 and 11.6 percent of vegetation fires, respectively (Figure 60). Collectively, deliberate causes (incendiary and suspicious combined) accounted for 53.5 percent of all fires, being the single largest cause of vegetation fires. Deliberate causes accounted for 59.6 percent of all fires for which a cause was assigned. Natural fires comprised 21.7 percent of WADEC vegetation fires. An additional 13.4 percent of fires resulted from accidental causes.

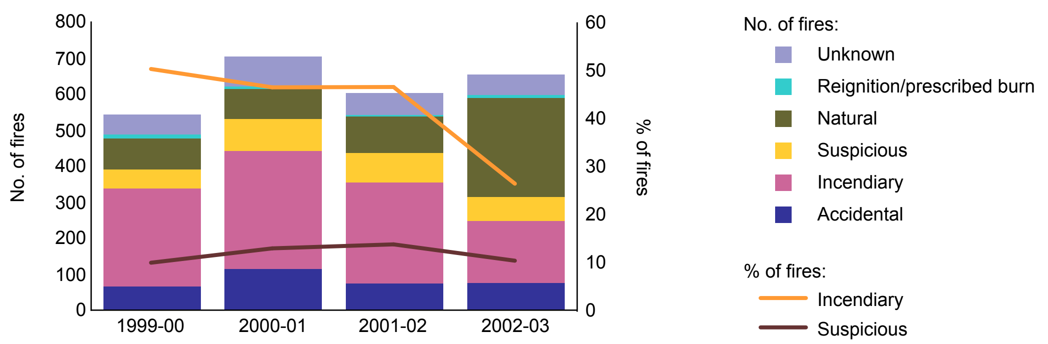
The greatest number of deliberate fires occurred in 2000–01 (n=417), and the lowest occurred in 2002–03 (n=239; Figure 59), despite the adverse fire conditions experienced in that year. Increased numbers of fires in 2002–03 principally resulted from the more than two-fold increase in the number of fires attributed to lightning; numbers of natural fires increased from 83 in 1999–2000 and 101 in 2001–02 to 275 in 2002–03.

The proportion of deliberate fires dropped from 59 to 60 percent for the first three years of the observation period, to 36 percent in 2002–03, reflecting both the increased proportion of natural fires and the genuine decrease in the number of deliberate fires (Figure 59). Whereas, natural fires, on average, comprised 15 percent of fires from 1999–2000 to 2001–02, and 42 percent of fires in 2002–03 were natural in origin. The decrease in the number of deliberately lit fires (principally in fires recorded as incendiary, as opposed to suspicious) is coincident with a marked reduction in deliberate fires FESA recorded in response to its targeted bushfire arson reduction programs (Ellis, Kanowski & Whelan 2004; Smith 2004; Figure 7).

Specific ignition factors

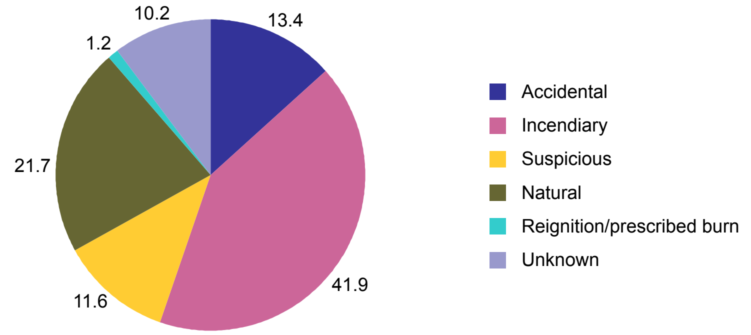
All fires classified as reignition/prescribed burn in Figure 59 and Figure 60 exclusively refer to escapes of prescribed burns being conducted by WADEC. Collectively, accidental fires comprised 13.4 percent of all vegetation fires WADEC attended (Figure 60). These derive from four distinct categories, namely: non-WADEC burn offs comprised 43 percent of all accidental fires, recreationists initiated a further 30 percent , the timber industry caused four percent and other industries accidentally caused the remainder. Subtle variations were evident in the number of fires resulting from these four causes each year. Collectively, the greatest number of accidental fires occurred in 2000–01, with increases evident across all four sub-categories (Figure 61).

Figure 59: Cause of fires each year



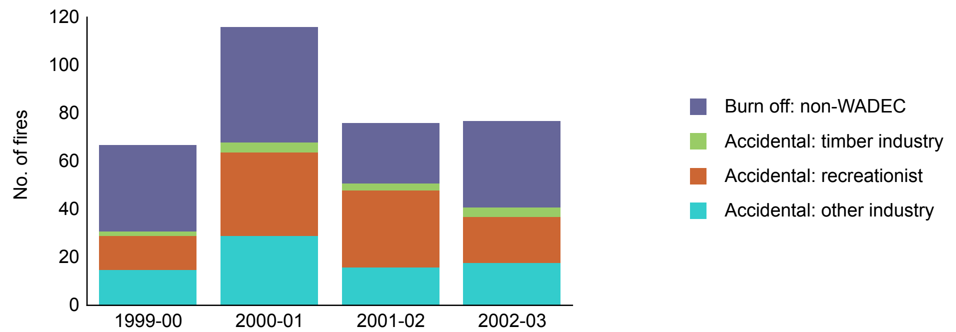
Source: WADEC 1999–2000 to 2002–03 [computer file]

Figure 60: Cause of fires (percent)



Source: WADEC 1999–2000 to 2002–03 [computer file]

Figure 61: Specific causes of accidental fires, by year (number)



Source: WADEC 1999–2000 to 2002–03 [computer file]

Location

The location of fires was examined by the region in which fires occurred and by land tenure.

Region

The distribution of WADEC regions is illustrated in Figures 62 and 63. The strong relationship between a high incidence of vegetation fires and higher population densities demonstrated in the FESA analysis is also clearly reflected in the WADEC data. Fifty-nine percent of vegetation fires WADEC attended occurred in the Swan region, which is centred on Perth (Figure 64). The majority of vegetation fires located outside the Swan region occurred in the South West (18%), Warren (10%) and South Coast (7%) regions (Figure 64).

The close relationship between fires and population is further demonstrated by the fact that of the 55 percent of fires WADEC attended in the Swan region were in the Perth division. A further 33 percent occurred in the Mundaring division and 12 percent were in the Dwellingup division (Figure 65).

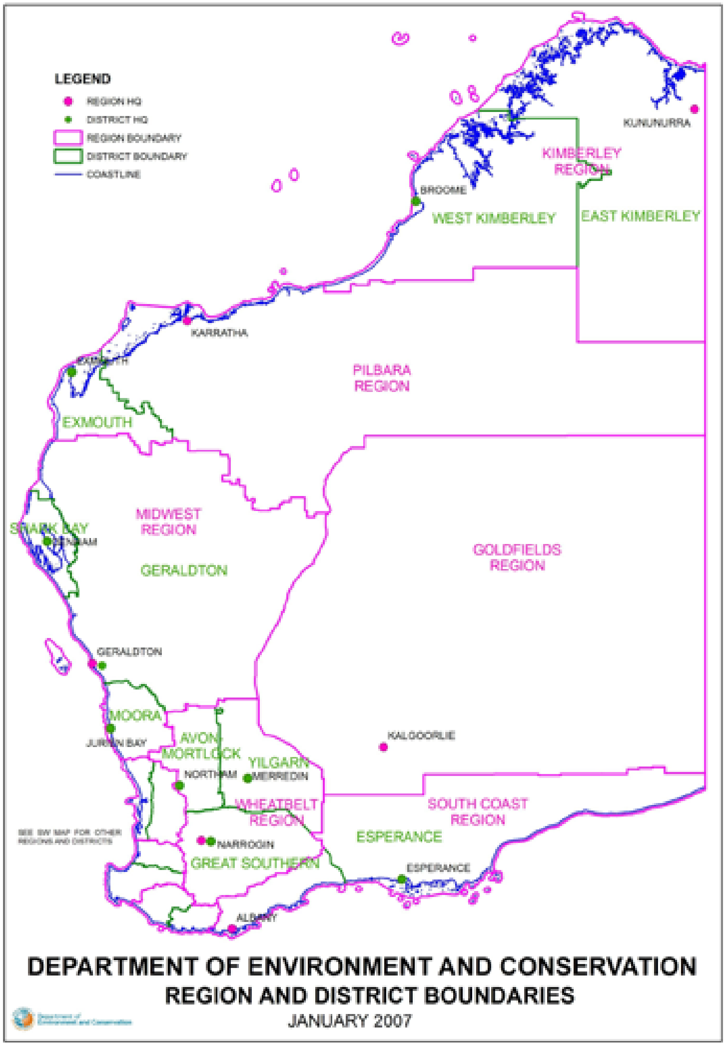
Overall, the proportion of deliberate fires was greatest in those areas experiencing the greatest numbers of fires (Figure 66). This was evident both on a regional scale, but also within the Swan region itself (Figure 65). Notably, deliberate causes were responsible for 70 percent of fires in the Swan region – consistent with the rates observed by FESA in that region – 42 percent of fires in the South West region, 35 percent of fires in the Warren region, and 23 percent of fires in the South Coast region were deliberate. Within the Swan region, deliberate fires accounted for 84 percent of fires in the Perth divisions but just 56 and 40 percent of vegetation fires in the Mundaring and Dwellingup divisions, respectively (Figure 67).

Deliberate fires accounted for 44 percent of WADEC-attended vegetation fires in the Kimberley region, but on average less than two deliberate fires occurred each year. WADEC recorded no deliberate fires in the Pilbara region, but unknown attributions were markedly higher than in other regions (Figure 66). At a division level, Manjimup, South West Capes, Merredin and Kununurra–East Kimberley all record a comparatively high proportion of deliberate fires (Figure 67).

Despite these anomalies, there was an exceptionally strong correlation between the number of deliberate vegetation fires and the total number of vegetation fires in a region ($r=.99$; $p <.001$). This strong correlation is also evident at a division level ($r=.98$; $p <.001$).

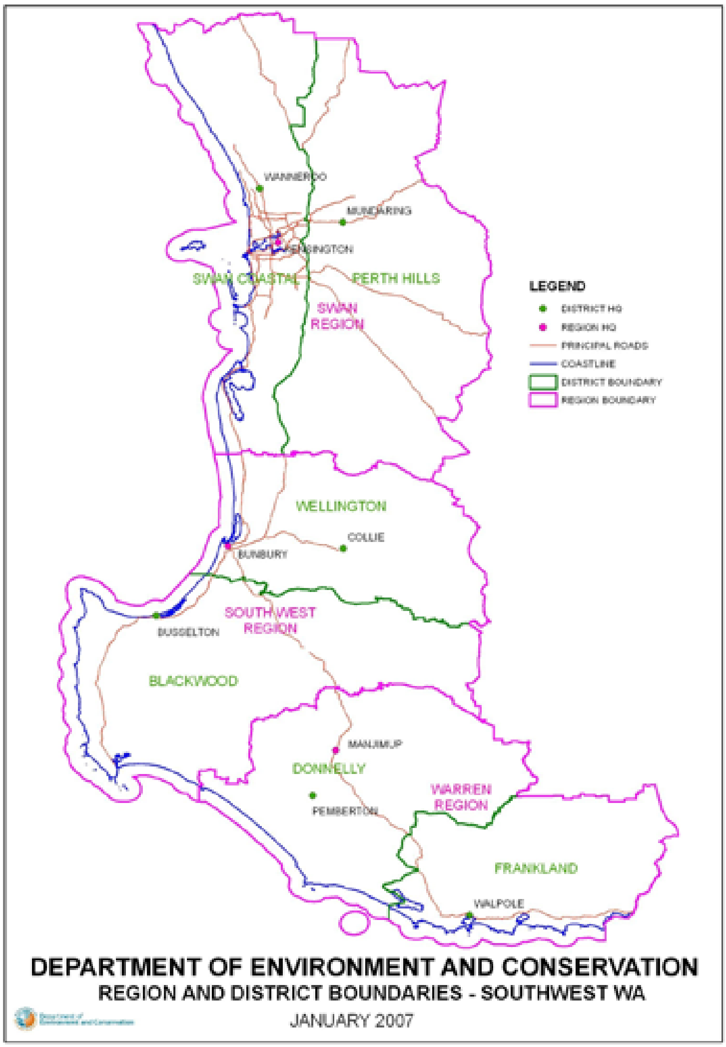
More remote locations in the state typically recorded higher proportions of natural ignitions, with a broad tendency for the proportion of natural fires to increase concomitant with decreasing proportions of deliberate lightings (Figure 66). Nevertheless, the actual numbers of natural fires documented tended to increase with increasing total fire frequency. Hence, the greatest numbers of natural fires were documented for the Swan region (Figure 68). This may reflect the fact that natural fires in more populated areas were more likely spotted and suppressed; many natural fires in remote areas are unlikely to be spotted, or may be allowed to burn because they fulfil ecological land management objectives.

Figure 62: WADEC regions for Western Australia



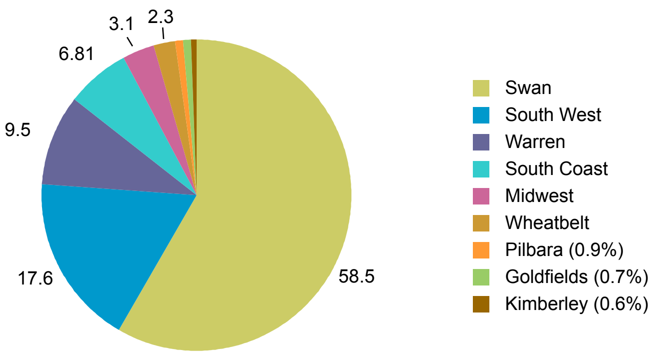
Source: © Western Australian Department Environment and Conservation 2007

Figure 63: WADEC regions in southwest Western Australia



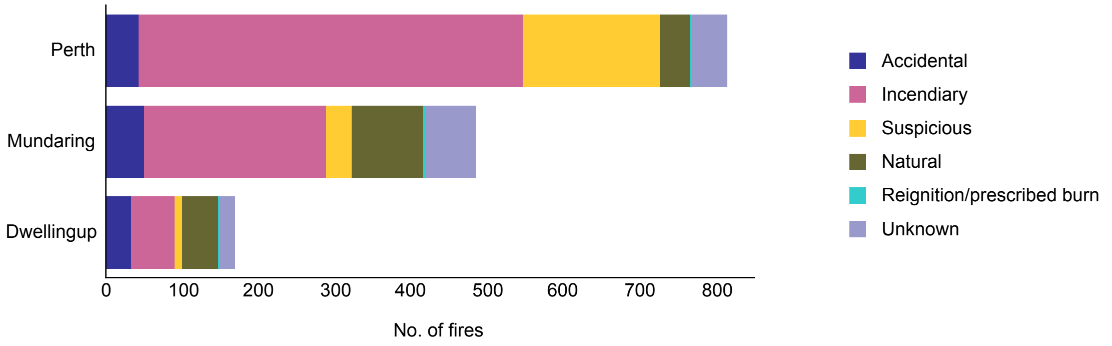
Source: © Western Australia. Department Environment and Conservation 2007

Figure 64: Location of fires, by region (percent)



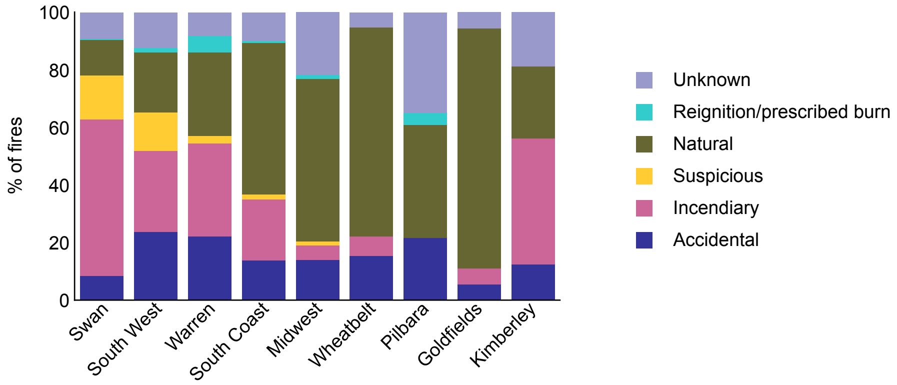
Source: WADEC 1999–2000 to 2002–03 [computer file]

Figure 65: Cause of fires in the Swan region, by division (number)



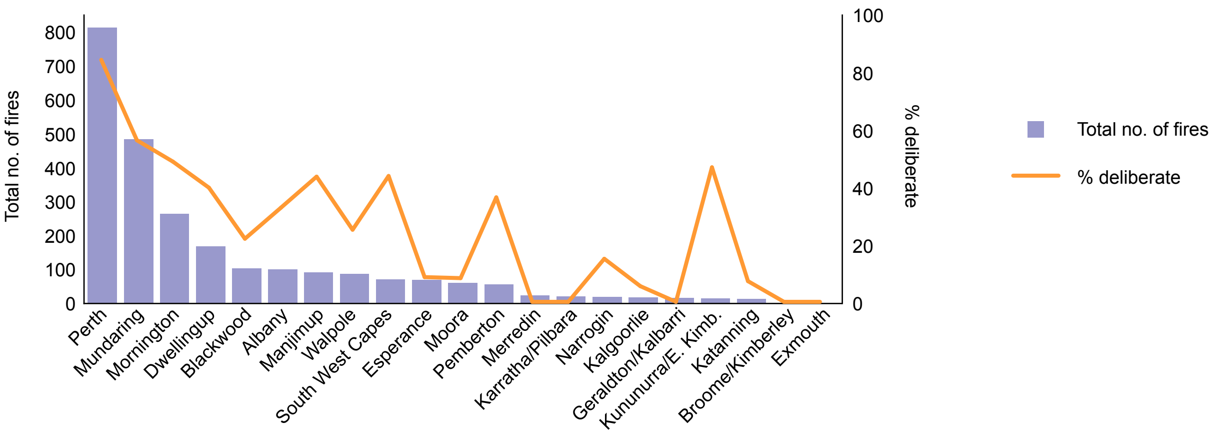
Source: WADEC 1999–2000 to 2002–03 [computer file]

Figure 66: Cause of fires (percent), and total number of fires, by region



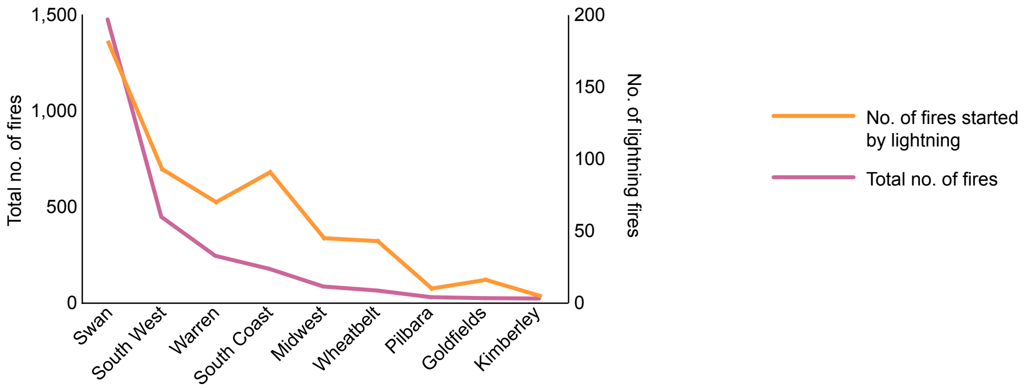
Source: WADEC 1999–2000 to 2002–03 [computer file]

Figure 67: Total number and proportion of deliberate fires, by division



Source: WADEC 1999–2000 to 2002–03 [computer file]

Figure 68: Natural and total fires, by region (number)



Source: WADEC 1999–2000 to 2002–03 [computer file]

Tenure

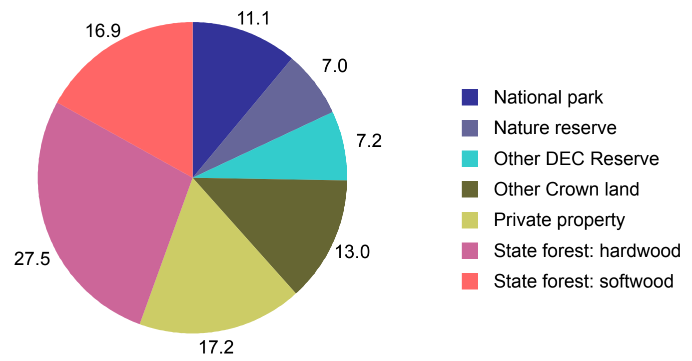
Collectively, 44 percent of vegetation fires WADEC attended occurred in state forests (hardwood 28%, softwood 17%; Figure 69). Eleven percent of vegetation fires occurred in national parks, seven percent each in nature reserves and in other WADEC reserves. Thirteen percent were on other Crown land and 17 percent were on private property.

The proportion of deliberate fires varied between tenures. Deliberate causes were responsible for 76 to 82 percent of fires in softwood state forests and on other WADEC reserves but only 53 to 54 percent of fires in hardwood state forests and other Crown land (Figure 70). In national parks and natural reserves deliberate causes were responsible for 38 to 41 percent of vegetation fires, respectively.

Natural causes comprised a much higher proportion of vegetation fires in national parks and nature reserves (38 to 43%), occurring at similar levels to deliberate fires in those tenures. Almost one-quarter of all fires in hardwood forests and other Crown land tenure also resulted from lightning. The greatest number and proportion of accidental fires occurred on private property.

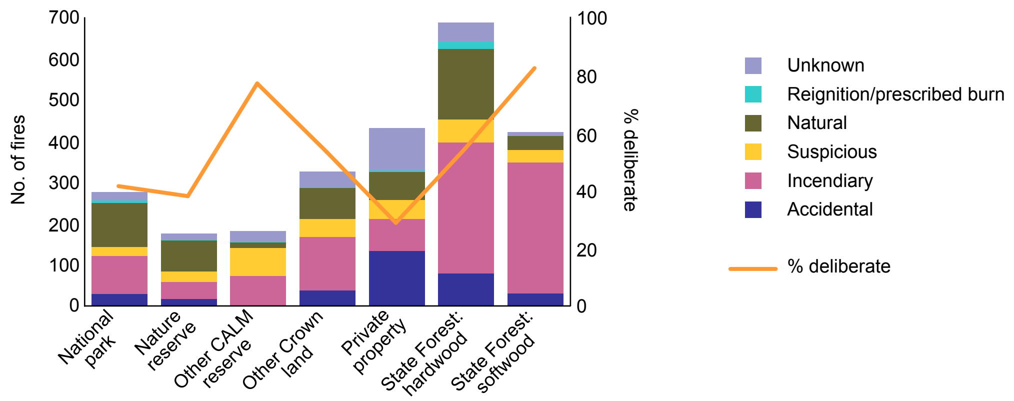
Collectively, 31 percent of all natural fires and 28 percent of all deliberate fires WADEC attended occurred in hardwood state forests. Twenty-six percent of all deliberate, but only six percent of natural fires, WADEC attended fires occurred in softwood state forests. In contrast, 19 percent of all natural fires, but only nine percent of all deliberate fires occurred in national parks. Similarly, 14 percent of all natural fires occurred in nature reserves, but just five percent of all deliberate fires occurred in that domain.

Figure 69: Fires, by tenure (percent)



Source: WADEC 1999–2000 to 2002–03 [computer file]

Figure 70: Cause of fires by tenure



Source: WADEC 1999–2000 to 2002–03 [computer file]

Timing

The timing of fires WADEC attended was examined by week of the year, by day of the week and by time of the day.

Week of the year

The natural timing of the bushfire seasons varies substantially across the state (Figure 5). This natural tendency is reflected in the timing of all fires WADEC attended. For example, fires in the Kimberley region principally occurred from April to September and fires in the Pilbara principally occurred from July to January, during the dry season (Figure 71). In contrast, most fires in the southern part of the state occurred from late October to late April (Figure 71 and Figure 72). The most intense period was between late October and mid February, coincident the period of lowest rainfall.

Overall, the increase in the number of fires at the beginning of the bushfire season and the decrease at the end of the season occurred systematically each year (Figure 73). This reflects the regularity with which periods of greatest rainfall end and to a lesser extent begin each year in many Western Australian regions (Figure 37).

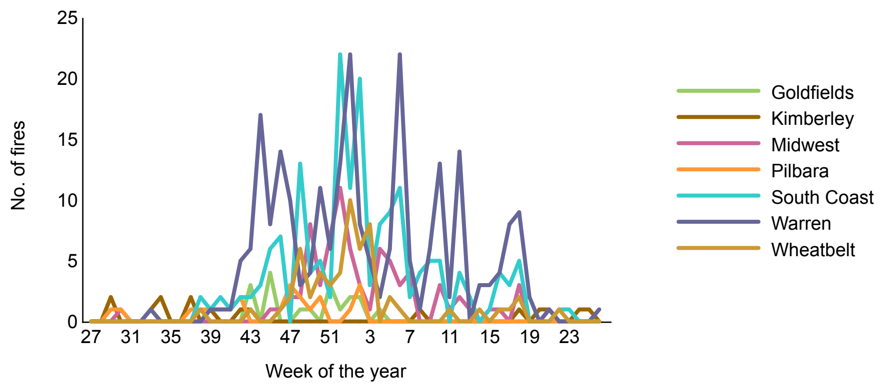
There was a tendency for WADEC to attend a greater number of vegetation fires before rather than after the New Year. This occurred for all years except 2001–02, when a large number of fires occurred during week 3 in January (Figure 73). Fifty-six of the 89 fires recorded during that week resulted from natural ignitions, but increased numbers of deliberate ignitions were also detected.

Marked differences were evident between the timing of fires based on cause (Figure 74). Most natural fires occurred in a comparatively short interval from mid December to late February, although a small spike was also evident in late March. Accidental fires principally occurred from mid October to mid April, but with higher numbers of fires at the beginning (weeks 42 to 50; mid October to mid December) and at the end (weeks 16 to 18; mid March to early April) of the fire danger season. These were principally escapes of non-WADEC burn offs, with rural burns typically undertaken just before and just after bushfire season. In contrast, a small number of recreational fires occurred from November through to April.

High numbers of incendiary and suspicious fires occurred from mid October to mid May, although the highest numbers were typically recorded during the first half of the bushfire season in southern Western Australia. Two major spikes in deliberate fires also occurred during weeks 44 to 46 (early to mid November) and from weeks 51 to 5 (mid December to early February). The latter peak represented a confluence between inherently high bushfire danger (as reflected by natural fires) and the school holidays. The increase in the number of deliberate fires from weeks 44 to 46 was not coincident with school holidays, but was observed in two out of four years. The number of deliberate fires during this period clearly outweighed non-deliberate causes.

The 2002–03 season was interesting from a number of perspectives. Although there was an inherently high fire danger in 2002–03, as indicated by the large number of natural fires, comparatively fewer vegetation fires were deliberately lit during this year (Figure 75). This likely reflects the extensive arson reduction campaigns undertaken in Western Australia during 2001–02 and 2002–03. One factor that distinguishes 2002–03 from previous years is the low incidence of deliberate fires during the first part of the season, up until the middle of January. In previous years the number of deliberate fires during the first part of the bushfire season clearly outweighed the later part. The decrease in early-season deliberate fires occurred despite the inherently adverse bushfire conditions, as reflected in the large high numbers of natural fires during December and early January. The greatest number of deliberate fires in 2002–03 occurred during the period that bushfires devastated large areas of eastern Australia, when media coverage of bushfires was likely at its highest. The high numbers of deliberate fires at this time does not appear to reflect more adverse bushfire conditions in Western Australia as comparatively few natural fires occurred during this interval.

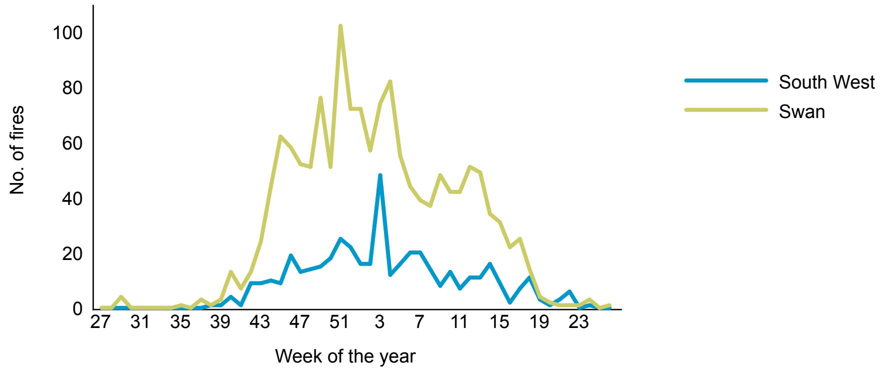
Figure 71: All fires by week of the year, for fires in selected WADEC regions



Note: week 1 pertains to the first week of January

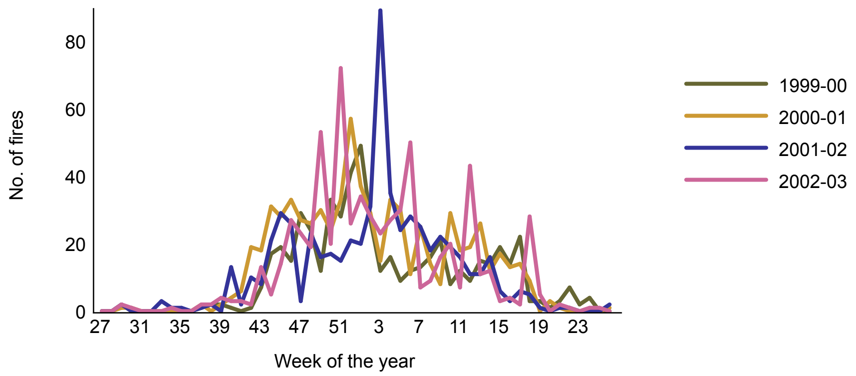
Source: WADEC 1999–2000 to 2002–03 [computer file]

Figure 72: All fires by week of the year for fires in the Swan and South West regions



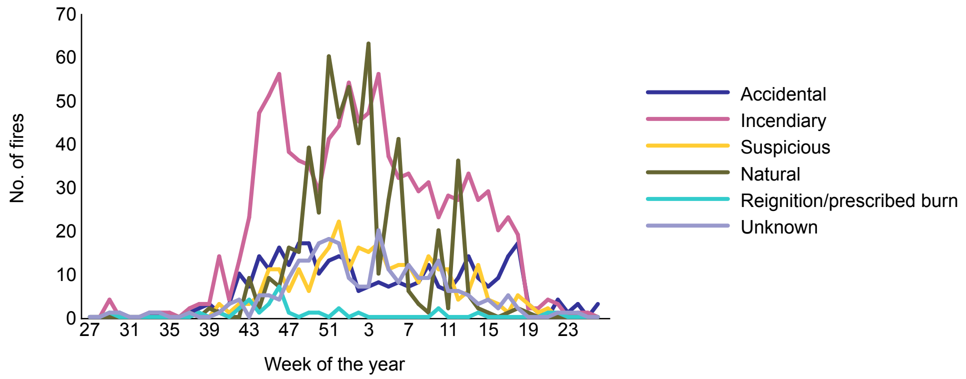
Source: WADEC 1999–2000 to 2002–03 [computer file]

Figure 73: All fires by week of the year, by year



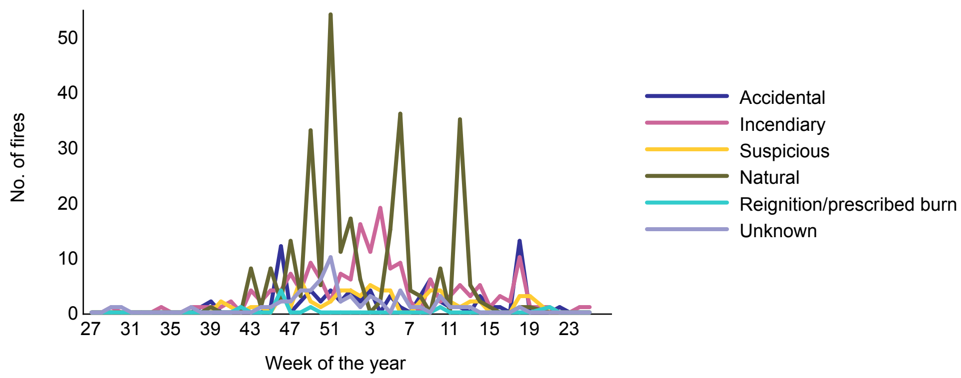
Source: WADEC 1999–2000 to 2002–03 [computer file]

Figure 74: Week of the year, by fire cause



Source: WADEC 1999–2000 to 2002–03 [computer file]

Figure 75: Week of the year, by cause, 2002–03



Source: WADEC 1999–2000 to 2002–03 [computer file]

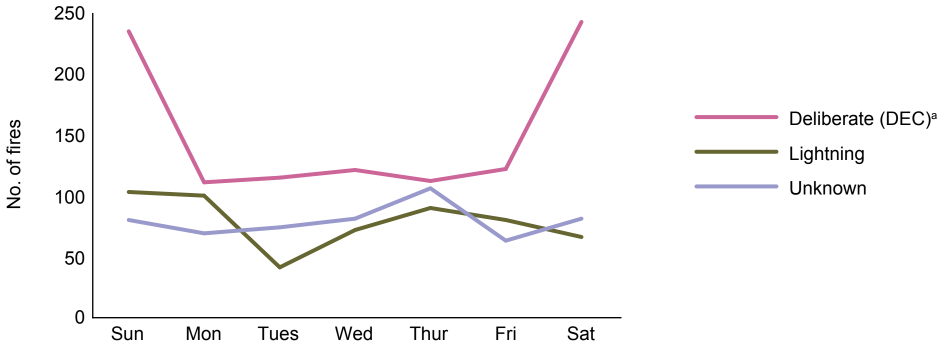
Day of the week

The distribution of fires by day of the week was highly cause-dependent. Incendiary fires were twice as likely to occur on Saturdays or Sundays as during the week (Figure 76), whereas suspicious fires were only 15 percent higher on weekend days. The number of non-deliberate vegetation remained comparatively uniform throughout the week, for most causes. This reflects the predominance of natural fires, industry-related accidental fires, and escapes from burn offs. However, 2.5 times more recreational fires occurred on Saturday and Sunday relative to the weekday average (Figure 77).

The greater number of deliberate fires on weekends occurred in all years except 2002–03, where the number of deliberate fires lit on weekends was comparable to that during the week (Figure 78). The number of fires lit on weekdays was comparable across all years. This implies that arson prevention and reduction measures may have affected the type of behaviour and/or practices that had previously commonly manifested on weekends. The cause of this turn-about in deliberate fire setting for 2002–03, particularly given the severity of the bushfire season, and its potential relationship to concurrent arson reduction campaigns is obviously of great interest.

The propensity for higher numbers of deliberate fires on weekends varied between regions. Higher number of deliberate fires on weekends was most prevalent in those regions that experienced the highest numbers of fires overall. Hence, the weekend effect was most clearly observed in the Swan region (Figure 79). In the South West, higher deliberate lightings occurred on both Saturdays and Sundays, but also on Thursdays, whereas for the South Coast and Warren regions high deliberate fire frequencies only occurred on Saturday (Figure 80).

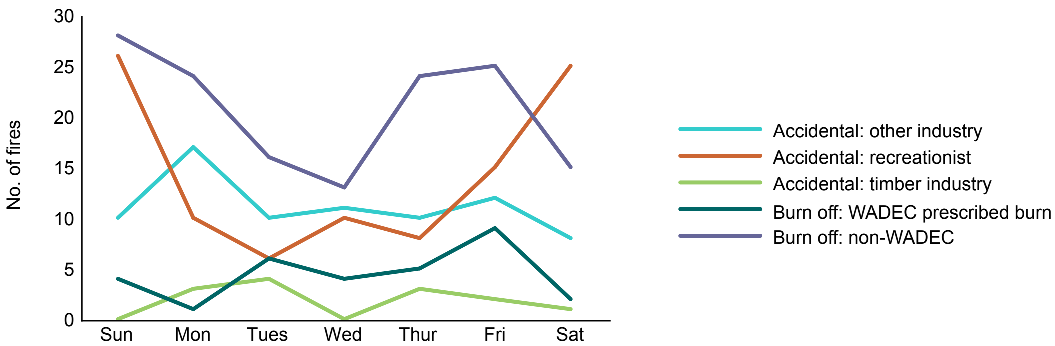
Figure 76: Day of the week for selected fire causes (number)[a]



a: deliberate fires according to the WADEC definition do not include suspicious fires; the above figure only includes fires classified as incendiary in this report

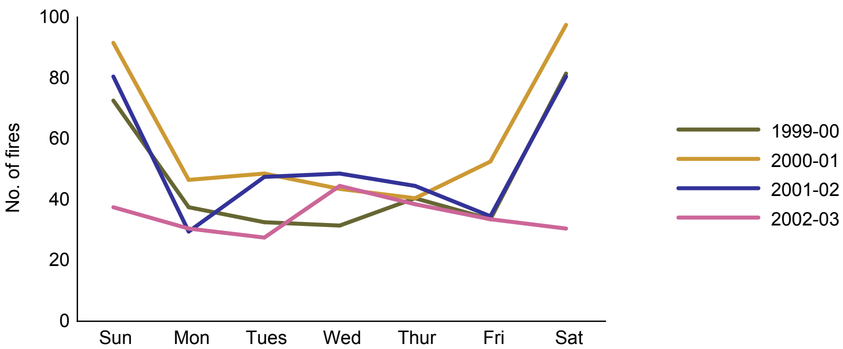
Source: WADEC 1999–2000 to 2002–03 [computer file]

Figure 77: Day of the week for non-deliberate, human–caused fires (number)



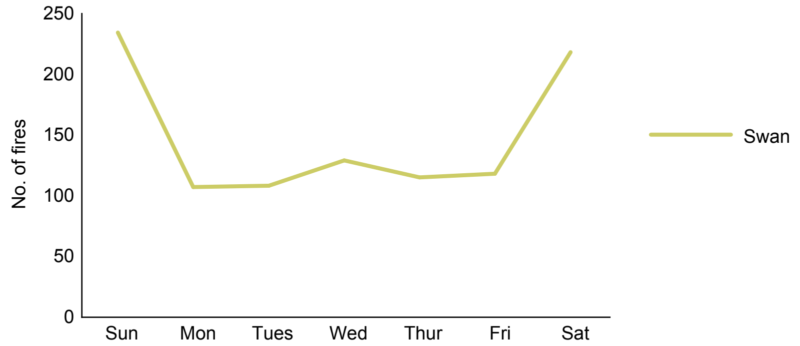
Source: WADEC 1999–2000 to 2002–03 [computer file]

Figure 78: Day of the week for deliberate fires, by year (number)



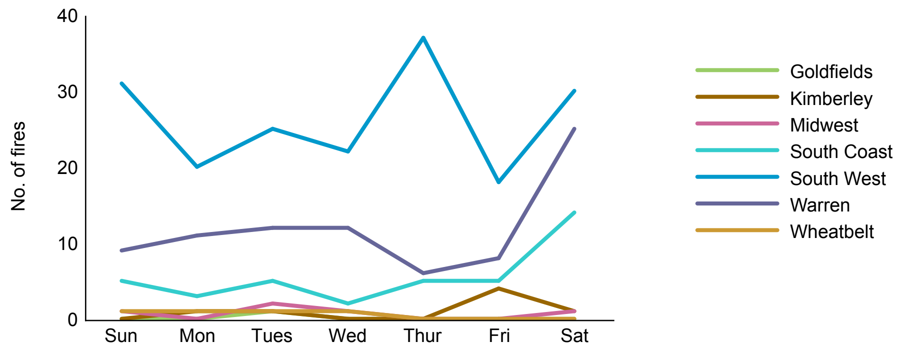
Source: WADEC 1999–2000 to 2002–03 [computer file]

Figure 79: Day of the week for deliberate vegetation for the Swan region (number)



Source: WADEC 1999–2000 to 2002–03 [computer file]

Figure 80: Day of the week for deliberate vegetation for other regions (number)



Source: WADEC 1999–2000 to 2002–03 [computer file]

Time of day

Distinctly different trends were evident between the distribution of detection times for WADEC and FESA fires. The majority of WADEC fires occurred during daylight hours, irrespective of cause, with 86 percent occurring between 6 am and 8 pm. Nevertheless, there were notable differences between the timing of fires of different causes (Figure 81).

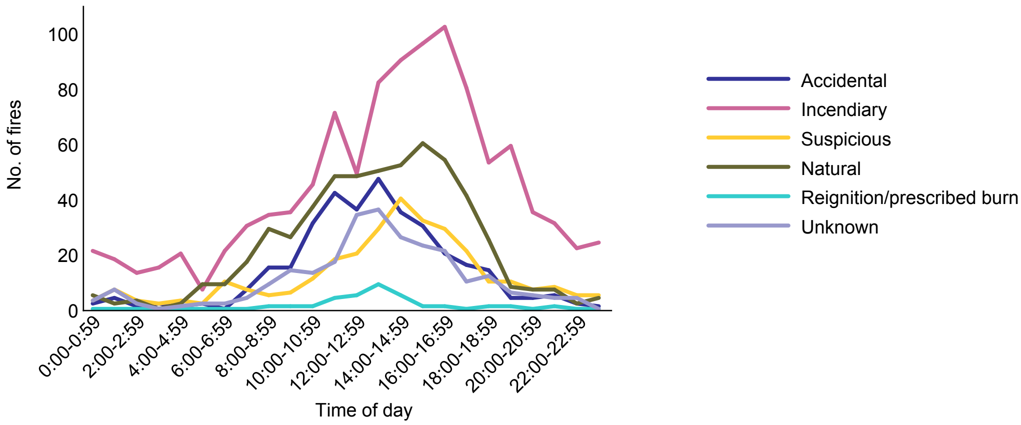
Peak numbers of deliberate fires occurred between 3 and 5 pm, somewhat later than that observed for non-deliberate fires. The peak number of accidental fires and prescribed burns (WADEC) occurred from 1 to 2 pm. Natural fires primarily occurred between 12 and 4 pm, with the peak being from 3 to 4 pm.

Twenty-two percent of WADEC-attended vegetation fires occurred between 6 pm and 6 am with only six percent occurring between midnight and 6 am. However, again variations in night fires were cause-specific. Fifty-two percent of deliberate fires occurred between 6 pm and 6 am, with 16 percent of deliberate fires occurring from midnight to 6 am. Deliberate causes accounted for 70 percent of all fires that occurred between 6 pm and 6 am and from midnight to 6 am. Although there were some differences, strong similarities were evident with the distributions of fires FESA attended.

The timing of fires was broadly consistent across regions (Figure 82). Nevertheless, the proportion of fires that occurred within specific intervals varied between and regions, reflecting differences in the proportion of deliberate fires but also differences in social patterns. For example, in the Swan region, the greatest number of deliberate fires between 10 and 6 am occurred in the Perth division, but fires within this timeframe accounted for a higher proportion of deliberate fires in the Mundaring and Dwellingup divisions.

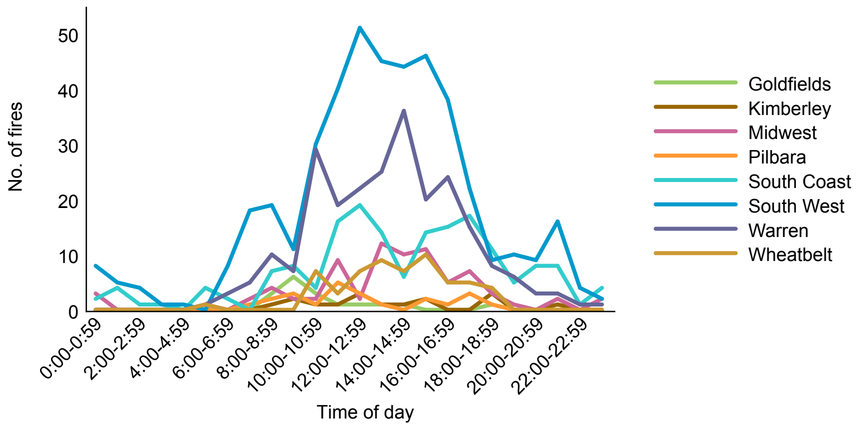
Greater numbers of deliberate fires on Saturday and Sunday principally occurred between 1 pm and 8 pm (Figure 83). This is in marked contrast to the trend observed in the FESA data where larger numbers of fires on the weekend reflected a high incidence of night-time fires on Friday night–Saturday morning and Saturday night–Sunday morning. No substantial difference was evident between the number of non-deliberate fires on the weekend and on other days of the week (Figure 84).

Figure 81: Detection time, by cause (number)



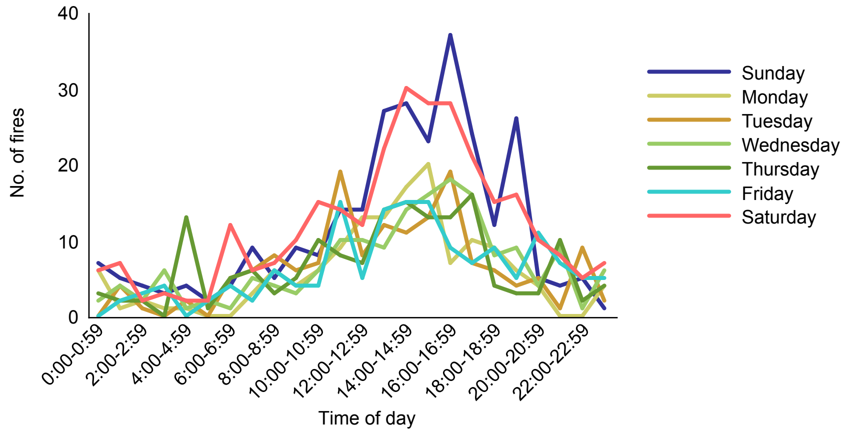
Source: WADEC 1999–2000 to 2002–03 [computer file]

Figure 82: Detection time, by region (number)



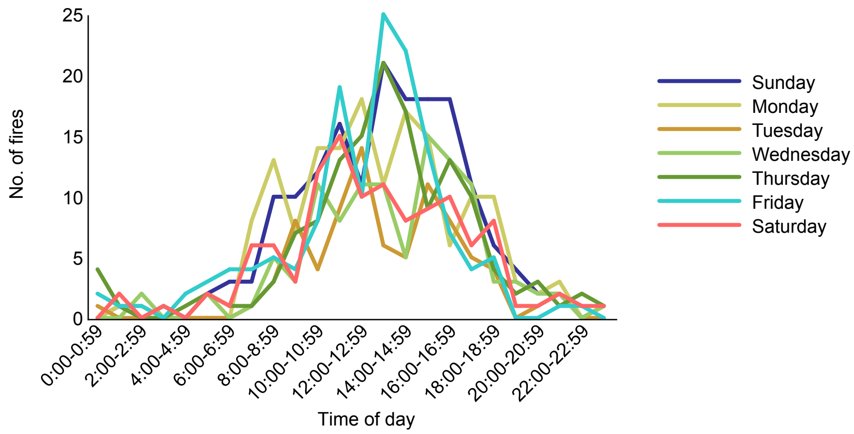
Source: WADEC 1999–2000 to 2002–03 [computer file]

Figure 83: Detection time of deliberate fires occurred, by day of the week



Source: WADEC 1999–2000 to 2002–03 [computer file]

Figure 84: Detection time of non-deliberate fires, by day of the week



Source: WADEC 1999–2000 to 2002–03 [computer file]

Area burned

The majority of fires WADEC attended were small; 50 percent of fires were less than 1 ha and 75 percent were less than 10 ha. Although there was a strong tendency for the number of fires to increase with increasing fire size, irrespective of cause (Figure 85), some differences were evident between the size distribution of individual causes.

The vast majority of deliberate fires were small; 86 percent were less than 10 ha and deliberate causes accounted for a decreasing proportion of fires as the area burned category increased (Figure 86). Nevertheless, deliberate fires were responsible for six fires of greater than 5,000 ha each. Two of these burned greater than 100,000 ha in the Kimberleys during 2002–03.

Although the majority of lightning fires were also small, lightning was the principal cause of large fires (Figure 85). Approximately three-quarters of fires of greater than 1,500 ha resulted from lightning, with natural fires accounting for an increasing proportion of fires as the area burned increased (Figure 86).

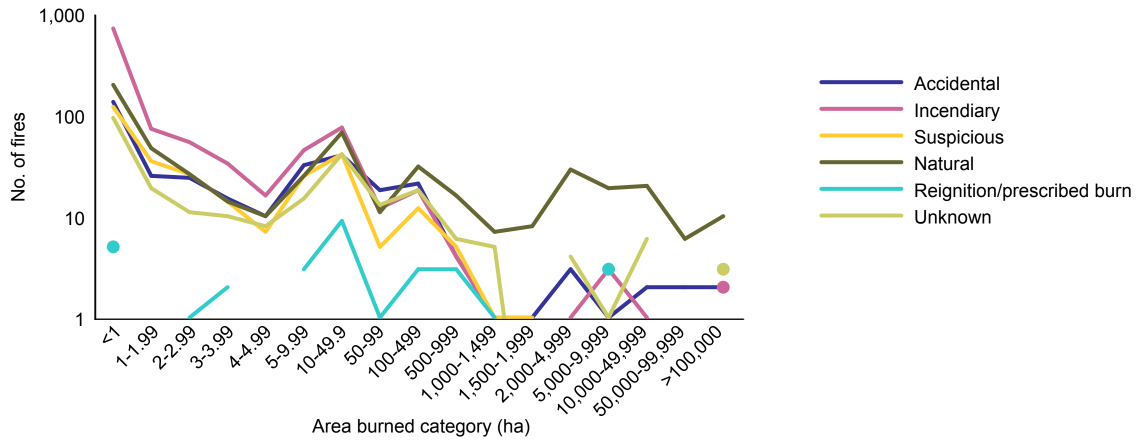
Statistics about the total area burned are naturally dominated by large fire events. Although deliberate fires were responsible for 54 percent of WADEC-attended fires, these contributed to less than seven percent of the total area burned between 1999–2000 and 2002–03, as overall the area burned in deliberate fires was typically small (Figure 87). The greatest total area was burned by natural (69%) and accidental (12%) fires.

The largest areas were burned during 2002–03 when 10 major fires individually burned in excess of 100,000 ha (Figure 88). Four of these fires were in the Kimberley, five on the South Coast and one was in the Wheatbelt region. Vast tracts of land were also burned on WADEC reserves in the Goldfields and Pilbara regions and fires greater than 10,000 ha occurred in all regions except the Swan and Warren. Deliberate fires were responsible for burning large areas in 2002–03; burning in excess of 100,000 ha in the Kimberley. Natural fires also burned extensive areas in 2000–01 and 2002–03 (Figure 88).

Given the location of the large fires in Western Australia, it is not surprising that the largest areas were burned in the South Coast, Pilbara, Kimberley and Goldfields regions. These were principally in sparsely populated areas dominated by savanna, desert or semi-desert. The overwhelming majority of land burned in the Goldfields, Wheatbelt and South Coast regions resulted from natural causes. Accidental fires featured most strongly in the Pilbara and Kimberley regions.

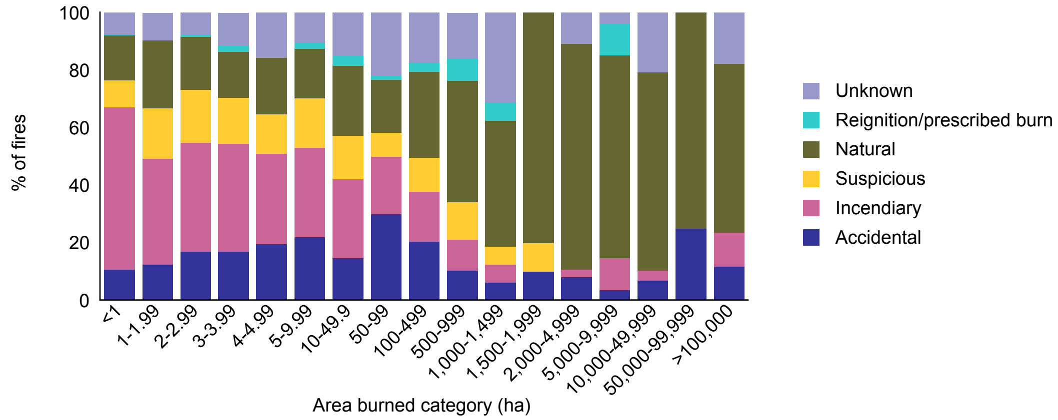
Although easy to overlook, in light of the large areas burned by natural fires, the role of deliberate fires was an important contributor to the areas burned in some areas. The greatest area burned (more than 100,000 ha) was burned by deliberate fires in the Kimberley region (Figure 89). Another 12,817 ha was deliberate burned on the South Coast, accounting for one percent of land burned in that region. Deliberate causes were a major contributor to the total area burned in the Swan region (18,824 ha), accounting for 27 percent of total area burned. The 2,742 ha of land burned by deliberate fires in the South West, represented 38 percent of total area burned in the region during the observation period. The Swan and South West regions were not only areas characterised by highest population densities and highest numbers of deliberate fires generally, but also have the greatest densities of forests, very high levels of biodiversity, and numerous vulnerable and endangered flora and fauna.

Figure 85: Area burned category, by cause (number)



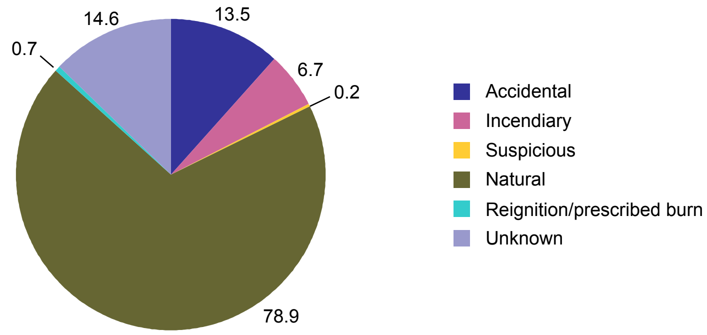
Source: WADEC 1999–2000 to 2002–03 [computer file]

Figure 86: Area burned category and total number of fires, by cause (percent)



Source: WADEC 1999–2000 to 2002–03 [computer file]

Figure 87: Total area burned, by cause (percent)

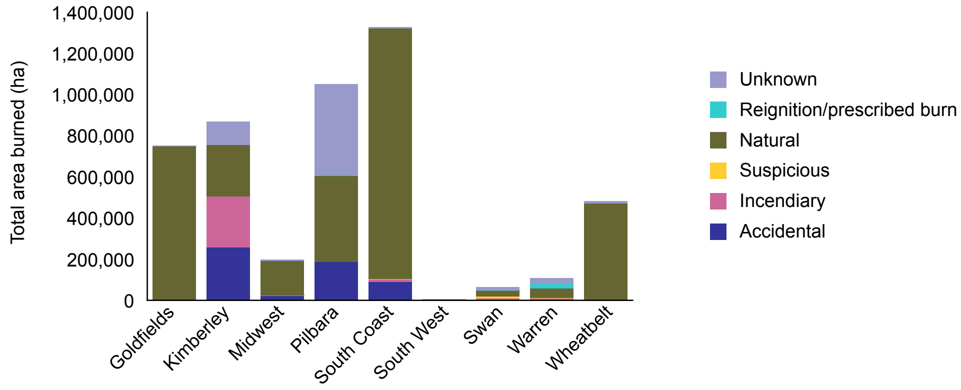


Source: WADEC 1999–2000 to 2002–03 [computer file]

Figure 88: Area burned, by each cause, each year (hectares)

Source: WADEC 1999–2000 to 2002–03 [computer file]

Figure 89: Area burned, by cause, within each region (hectares)



Source: WADEC 1999–2000 to 2002–03 [computer file]

Vegetation

The WADEC database included detailed information about the vegetation burned in 83 percent of cases. Information about the damage to ecosystems was also recorded in 31 percent of fires.

The greatest number of fires occurred in northern jarrah and *Pinus pinaster* (Table 3). Sixty-eight percent of fires in northern jarrah occurred in state forest (hardwood), with just over half (54%) of fires in this vegetation type being deliberately lit. Ninety-five percent of fires in *Pinus pinaster* also occurred in state forests (softwood); 86 percent of fires in *Pinus pinaster* were deliberately lit.

High numbers of fires were also burned in banksia woodland (all tenure categories), grassland (commonly on private property), heathland (commonly national park or other Crown land) and low open woodlands (most tenure categories). The proportion of deliberate fires was variable between these vegetation categories, being highest in banksia woodland and to a lesser extent low open woodland, but comparatively low in grasslands, where fires were commonly the result of accidental fires on private property.

In production forests, fires most commonly resulted in crown scorch. However, in 12 percent of cases the regenerating vegetation was killed (Figure 90). Deliberate causes were responsible for 66 percent of instances of crown scorch in production forests, but only 43 percent of regeneration being killed.

Although fires in conservation forest most commonly resulted in crown scorch, defoliation of the crown or scorching of regenerating forests (Figure 90), deliberate fires potentially had substantial ecological impacts in WADEC reserves:

- in seven out of the 10 cases where fires killed regenerated areas in conservation reserves, deliberate causes were responsible
- all seven fires that occurred in fire sensitive ecosystems containing endangered and rare fauna resulted from deliberate lightings; the largest burned 100 ha
- deliberately lit fires accounted for 60 percent of the 134 fires in fire sensitive ecosystems
- 23 of the 34 fires in Tuart (endemic to South West Western Australia) reserves, 26 of the 54 fires in southern jarrah forests and approximately 30 percent of Karri forests resulted from deliberate lightings.

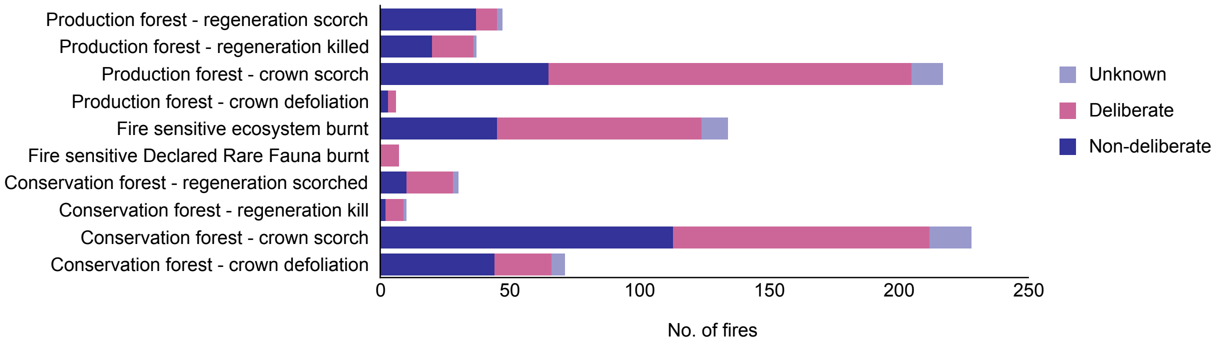
In the 31 percent of cases were ecosystem damage was assessed, 901,000 ha of conservation forest and 457,000 ha of fire sensitive ecosystems was affected, with the largest area having been burned in heathland, spinifex, savanna woodland, mallee, mulga and low open woodlands. The majority of this was not the result of deliberate lightings. Of the 35,000 ha of northern jarrah burned, 5,800 ha resulted from deliberately lit fires. Similarly, the majority of the 15,500 ha of karri forest burned did not result from deliberately lightings. Nevertheless the potential for ecosystem damage is again reflected in the fact that 80 percent of the 695 ha of Tuart forest burned, one-third of the 21,411 ha of southern jarrah burned, and all 166 ha burned in reserves containing endangered and rare fauna were deliberate lit.

Table 3: Number, percentage of deliberate fires, and tenure of fires based on vegetation type

Vegetation type	Total no. of fires	% deliberate	National park	Nature reserve	Other WADEC reserve	Other Crown land	Private property	State forest hardwood	State forest softwood
Northern jarrah	708	54.0	9.5	2.5	4.7	6.9	7.3	67.9	1.1
Missing	428	39.5	11.7	11.9	6.8	17.3	20.6	18.5	13.3
Pinus pinaster	306	85.9				1.3	1.3	2.6	94.8
Banksia woodland	218	79.8	9.6	13.3	17.9	21.1	17.9	11.9	8.3
Grasslands	185	36.2	3.2	3.8	9.2	10.3	69.2	1.6	2.7
Heathland	119	47.1	29.4	18.5	9.2	31.1	11.8	0.0	0.0
Low open woodlands	103	56.3	19.4	12.6	18.4	23.3	19.4	5.8	1.0
Unforested flats	63	60.3	12.7	19.0	23.8	17.5	15.9	6.3	4.8
Other	59	45.8	8.5	5.1	6.8	25.4	25.4	22.0	6.8
Southern jarrah	54	48.1	18.5		1.9	3.7	13.0	61.1	1.9
Pinus radiata	53	32.1	1.9			13.2	20.8	9.4	54.7
Tuart	34	67.6	32.4	5.9	23.5	11.8	11.8	14.7	0.0
Mallee	31	3.2	19.4	22.6		54.8	3.2	0.0	0.0
Pure Karri	31	32.3	38.7			3.2	22.6	32.3	3.2
Wandoo	31	25.8	12.9	9.7	6.5	6.5	22.6	41.9	0.0
Other forest type	16	43.8	6.3	6.3	12.5	25.0	37.5	12.5	0.0
Crops	15	20.0				0.0	80.0	6.7	13.3
Spinifex	14	7.1	42.9	7.1	7.1	35.7	7.1	0.0	0.0
Acacia scrub	11	45.5		54.5	9.1	18.2	18.2	0.0	0.0
Tingle	8	0.0	100.0			0.0	0.0	0.0	0.0
Savanna woodland	7	42.9	71.4			0.0	14.3	14.3	0.0
Pinus (other species)	5	80.0	20.0			0.0	0.0	0.0	80.0
Karri mixed	4	50.0				50.0	25.0	0.0	25.0
Mallet	3	0.0		33.3	0.0	33.3	33.3	0.0	0.0
Saltbush or Bluebush	3	0.0	33.3			0.0	66.7	0.0	0.0
Mulga scrub	2	0.0		50.0		50.0	0.0	0.0	0.0
Total	**2,511**								

Source: WADEC 1999–2000 to 2002–03 [computer file]

Figure 90: Cause of fire, by ecosystem damage (number)



Source: WADEC 1999–2000 to 2002–03 [computer file]

Summary

Western Australia incorporates approximately one-third of the Australian continent. Important points about vegetation fires in this state are summarised as:

- Australian Productivity Commission reports indicated that FESA and WADEC attended 11,842 fires in 2000–01 and 11,309 in 2001–02. This is marginally lower than the figures derived from the combined FESA and WADEC data, which indicated attendance at 12,486 fires in 2000–01 and 11,823 in 2001–02. While both data sources provide a broad guide as to the number of vegetation fires Western Australian fire services attended, it is recognised that actual number of fires may be somewhat higher owing to large numbers of natural and human-caused ignitions that took place in the tropical savannas of northern Western Australia, that are not attended by fire agencies.
- Between 90 and 95 percent of fires are attended by the Fire and Rescue Service (career and volunteer) and Bush Fire Service, and combined fire services like the volunteer Emergency Service Units, and hence are reported under the umbrella of FESA fire services. Less than 5 to 10 percent of fires are attended by WADEC.
- FESA and WADEC recorded peak numbers of fires for 2000–01. By 2005–06, the introduction of a number of measures to reduce vegetation fires, including targeted arson reduction programs had almost halved the number of vegetation fires attended in any one year. Hence, some specific observations made within this analysis are no longer relevant to the situation in Western Australia. However, the overarching generalisations about the typical causes, timing and distributions of vegetation fires are likely the same, and therefore of relevance to Western Australian fire services as well as fire services in other jurisdictions.

Cause of fires: Although the data available for the FESA analysis were incomplete, some broad generalisations can be made about the principal causes of fires in Western Australia, namely:

- Most fires in Western Australia were deliberate in origin; of the approximately 60 percent of FESA fires for which causal information was available for 2000–01 to 2001–02 in the AFAC–FESA database, 69 percent were deliberate (9% incendiary, 60% suspicious). Fifty-four percent of WADEC-attended fires from 1999–2000 to 2002–03 were also classified as deliberate (42% incendiary, 12% suspicious).

- Natural fires accounted for 22 percent of WADEC-attended fires but only 1.6 percent of fires documented in the AFAC–FESA database.
- Approximately 15 percent of AFAC–FESA and 13 percent of WADEC fires were classified as accidental. However, accidental fires WADEC attended principally resulted from escapes of non-WADEC burns (43%), accidental fires causes by industries (26%), and escapes from recreational fires (30%), whereas 47 percent of accidental AFAC–FESA fires were smoking-related, with a further 18 percent being non-deliberate child fires.
- Non-deliberate child fires accounted for 2.7 percent of AFAC–FESA fires for 2000–01 to 2001–02, but this likely significantly underestimates the role of children in vegetation fire ignitions, as many fires started by children were likely classified as incendiary or suspicious or the person responsible for fires was not identified.
- Twelve percent of AFAC–FESA vegetation fires were smoking-related.

Location: The location of vegetation fires is summarised in terms of geographic distribution (region, SSD, SLA, postcode) and complex type.

Region/SSD/SLA/postcode: The distribution of vegetation fires was intimately linked with distribution of people although no one-to-one correlation existed between population and the number of fires occurring in a given area (for example, postcode or SLA):

- Between 50 and 90 percent of all vegetation fires attended in Western Australia occurred in the Perth region, with the greatest numbers occurring in outer metropolitan SSDs.
- Population densities also affected fires attended in neighbouring reserves, national parks and state forests; 59 percent of all fires WADEC attended occurred in the Swan region.
- High densities of fires in regional areas were also associated with regional population centres.
- A small number of locations accounted for a high proportion of fires within individual areas, be they those areas characterised by low, moderate or very high numbers of vegetation fires; in the Perth region, the eight postcodes in the South East, seven in the North and four in the South West Metropolitan SSDs that recorded in excess of 200 vegetation fires (total) in two years were responsible for 66 to 83 percent of all fires in those SSDs, and were collectively responsible for approximately two-thirds of all fires in the Perth region.
- However, the degree of concentration/dispersal of vegetation varied between areas; in some areas very high fire numbers may have been experienced in just a couple of postcodes, whereas in other areas, moderately high numbers of fires occurred in most postcodes within that area.
- The number of deliberate fires correlated with total number of fires; regions, SSDs, SLAs and postcodes characterised by the highest numbers of fires were characterised by highest numbers of deliberate fires; high proportions of deliberate causes were recorded across all SSDs, SLAs and postcodes that recorded high numbers of fires overall.
- Individual postcodes in the Perth region typically recorded between five and 200 fires in total and between one and 100 deliberate fires, per 10,000 people per year (based on 2000–01 to 2001–02 data), although higher values were recorded in several postcodes. Maximum recorded values in 2001–02 have markedly reduced following introduction of targeted arson reduction measures.
- The distribution of non-deliberate child fires paralleled the distribution of vegetation fires generally; most occurred in the Perth region, with high numbers being observed in postcodes recording high numbers of fires generally. However, not all postcodes recording high numbers of fires also documented high numbers of non-deliberate child fires.

- The number of smoking-related fires also broadly correlated with the distribution of vegetation fires generally. However, smoking-related fires accounted for 49 percent of vegetation fires in the central Perth region, as compared with 12 to 18 percent of fires in outer metropolitan areas, and commonly two to four percent of vegetation fires in regional Western Australia.

Complex: Most vegetation fires occurred on unused property or Crown land, followed by parks and reserves, on roads, and around dwellings and schools. High proportions of deliberate fires were evident across all complexes that experienced high numbers of fires, although slightly lower rates along road complexes reflected increased proportions of smoking-related fires.

Timing: Important aspects of the timing of vegetation fires in Western Australia are summarised in terms of the time of the year, day of the week and the time of day at which they occurred.

Week of the year: Most fires, irrespective of cause, occurred during the bushfire danger season, which varies substantially across the state. Subtle variations were also evident between causes. Hence:

- FESA recorded high numbers of fires in the North West region from July to January; WADEC recorded higher numbers in the Kimberley from April to September and in the Pilbara from July to January.
- High fire numbers in the southern half of the state coincided with the summer months, although variations were evident with latitude and, in the case of WADEC-attended fires, by fire cause. FESA recorded the highest numbers of fires on the Coral Coast from mid October to mid January; a similar peak existed for the Perth region although fire numbers in that region remained elevated until late April. Fires were highest in the South West from mid October to mid February.
- The timing of the increase in fire numbers for both FESA and WADEC occurred at a similar time every year, but the cessation of the bushfire season was less predictable in the FESA data. The regularity in fire frequencies reflects the comparative predictability of climatic cycles in this region.
- Systematically higher weekly average fire numbers occurred late in the calendar year in virtually all SLAs in the Perth region. A similar trend was evident in the WADEC data for southern Western Australia.
- Where FESA typically recorded strong correspondence between the timing of deliberate and non-deliberate fires in a given year, differences were evident between the timing of accidental and deliberate fires WADEC attended, a reflection of the increase in the number of fires resulting from escapes of burn offs just before and after the bushfire season. Peak numbers of natural fires occurred from the beginning of December to the end of February.
- Increases in non-deliberate child fires commonly coincided with school holidays but spikes in fire frequency also occurred in the middle of the first and last terms of the school year.

Day of the week: Higher numbers of fires occurred on weekends relative to weekdays, but the proportion of fires occurring on a weekend were cause and location dependent.

- **AFAC–FESA**: 52 more deliberate fires occurred on Saturday and 46 percent more occurred on Sunday than on the average weekday; this compared with an increase of 36 percent and 21 percent on Saturday and Sunday, respectively, for accidental fires. Increased numbers of deliberate fires on weekends principally reflected an increase in the number of deliberate fires on Friday night–Saturday morning and Saturday night–Sunday morning. In relation to specific accidental causes, smoking-related fires were higher on Saturday but not Sunday, whereas 58 percent higher numbers of non-deliberate child fires occurred on both Saturday and Sunday relative to the weekday average.

- **WADEC**: recorded between 80 and 85 percent more deliberate fires on Saturday and Sunday than during the week. In contrast, 43 percent more accidental fires occurred on Sunday and 10 percent more on Saturday, relative to the weekday average. However, cause-specific variations were evident within the accidental category; escapes of recreational fires were more than twice as high on a weekend, but fires resulting from many industries were less frequent on weekends. Reduced numbers of weekend fires were evident during 2002–03, being comparable to that observed on weekdays; the decrease in deliberate fires on weekends was the principal contributor to reduced numbers of deliberate fires in 2002–03. It is unclear if or how this reduction in weekend fires relates to the introduction of arson prevention measures introduced by FESA and/or WADEC.

Time of day: Differences were evident in the timing of fires, based on cause, location and, in some cases, day of the week.

- **AFAC–FESA**: most non-deliberate fires occurred during daylight hours with peak numbers occurring between 2 and 3 pm. In contrast, deliberate fires defined a bimodal distribution, characterised by an asymmetrical daytime peak that reached a maximum at 3 to 4 pm – coincident with the peak in non-deliberate child fires – and a distinct ‘night’ peak, that reached a maximum at midnight. Half of all deliberate fires in the Perth and South West regions occurred between 7 pm and 6 am with 19 percent occurring between midnight and 6 am. Although deliberate fires at night occurred on all days of the week, the greatest number occurred on Friday night–Saturday morning and Saturday night–Sunday morning. Differences were, however, observed between locations.
- **WADEC**: peak numbers of accidental fires and prescribed burns (WADEC) occurred between 1 and 2 pm, whereas the peak in deliberate fires occurred between 3 and 5 pm. While only 22 percent and six percent of all WADEC-attended fires occurred between 6 pm and 6 am and between midnight and 6 am, respectively, 52 percent of deliberate fires occurred between 6 pm and 6 am, with 16 percent of deliberate fires occurring from midnight to 6 am.

Area burned (WADEC only): overall fire frequency decreased with fire size, irrespective of cause, but deliberate fires typically accounted for a decreased proportion, and natural fires contributed an increased proportion of fires as fire size increased. Statistics about total area burned were dominated by large fire events; the greatest total area was burned by natural fires; the largest areas were burned in 2002–03; the greatest total area was burned in the least populated regions (South Coast, Pilbara, Kimberley and Goldfields). Deliberate causes accounted for less than seven percent of the total area burned, with the largest areas burned by deliberate fires occurring in the Kimberley region (dominated by a single fire event). However, deliberate causes accounted for a higher proportion of the total area burned in both the Perth and South West regions, areas where deliberate fires are most problematic and fire size is generally smaller.

Type of incident (FESA only): 94 percent of fires FESA documented from 2000–01 to 2006–07 were scrub or bush and grass mixtures; and only 0.2 percent were forest or wood fires greater than one hectare.

Vegetation (WADEC only): The greatest numbers of fires occurred in northern jarrah and *Pinus pinaster*, principally within state forest plantations. Deliberate causes accounted for 54 percent of fires in northern jarrah and 86 percent of all fires in *Pinus pinaster*. High numbers of fires also occurred in species-rich Banksia woodlands, and heathlands, with deliberate fires accounting for 80 and 47 percent of fires in these locations, respectively. While fires were typically small, deliberate ignitions led to significant ecological damage. Deliberate ignitions were the leading cause of vegetation death in regenerating vegetation in conservation reserves. In addition, there are the potential impacts placed on specific vulnerable, endangered and rare flora and fauna. Deliberate ignitions were the only listed cause of fires in fire-sensitive ecosystems containing declared and rare fauna. Similarly, 23 of the 34 fires in Tuart reserves

– a species endemic to South West Western Australia – were deliberate, with deliberate ignitions being responsible for 80 percent of the total 695 ha of Tuart forest burned in the four year period.

Fire danger, fire restrictions and total fire bans (FESA only): The majority of fires in Western Australia occurred under high fire danger conditions, but only one percent of fires in the AFAC–FESA database occurred under extreme fire conditions. The distribution of recorded fire danger indices was largely in accord with the distribution of fire danger conditions experienced during the Western Australian bushfire danger season. Deliberate ignitions accounted for a decreased proportion of fires as fire danger increased from high to extreme. Three-quarters of the fires in Western Australia took place when no fire restrictions or bans were in place. Fires occurring during a total fire ban were most likely to take place in those areas that experienced high numbers of fires overall; almost 80 percent of fires lit during TFB occurred in the 24 postcodes that recorded 100 or more fires per year.

Sources of information

ABS 2001a. *Australian standard geographical classification*. ABS cat. no. 1216.0. http://www.abs.gov.au/ausstats/abs@.nsf/cat/1216.0

ABS 2001b. *Postal area to statistical local area concordance, Australia, 2001*. ABS cat. no. 1253.0. http://www.abs.gov.au/ausstats/abs@.nsf/cat/1253.0

ABS 2005a. *Population by age and sex, Western Australia*. ABS cat. no. 3235.5.55.001. http://www.abs.gov.au/ausstats/abs@.nsf/cat/3235.5.55.001

ABS 2005b. *Tourism region maps and concordance files, Australia, 2005*. ABS cat. no. 9503.0.55.001. http://www.abs.gov.au/ausstats/abs@.nsf/cat/9503.0.55.001

ABS 2006. *Australian demographic statistics*. ABS cat. no. 3101.0. http://www.abs.gov.au/ausstats/abs@.nsf/cat/3101.0

Australia. Department of Environment and Heritage 2001a. *Land use, Western Australia*. Accessed through http://audit.deh.gov.au/ANRA/atlas_home.cfm

Australia. Department of Environment and Heritage 2001b. *Native vegetation types and extent: Western Australia*. Accessed through http://audit.deh.gov.au/ANRA/atlas_home.cfm

Australian Bureau of Meteorology 2007a. *Average rainfall, annual: Western Australia*. Accessed through http://www.bom.gov.au/cgi–bin/climate/cgi_bin_scripts/annual–monthly–rainfall.cgi

Australian Bureau of Meteorology 2007b. *Cyclone and fire, southwest WA: 1937, 1961, 1978*. http://www.bom.gov.au/lam/climate/levelthree/c20thc/fire1.htm

Australian Bureau of Meteorology 2007c. *Fire seasons in Australia*. http://www.bom.gov.au/climate/c20thc/fire.shtml

Ellis S, Kanowski P & Whelan R 2004. *National Inquiry into Bushfire Mitigation and Management*. Canberra: Commonwealth of Australia. http://www.coagbushfireenquiry.gov.au/findings.htm

Smith RD 2004. *Community centred bush fire (arson) reduction: are we prepared for future challenges? 11th Annual AFAC Conference and Inaugural Bushfire CRC Conference, 7–9 October 2004, Pert*h. Western Australia. West Perth: Conference Secretariat.

South Australia

Contents

The first part of this chapter provides **contextual information** on South Australia, including basic information regarding its climate, geography, land use and population. It also provides an outline of the bushfire regimes, historically important bushfire events, and overview of fire services in South Australia. The second part represents an **analysis of data** provided by the South Australian Metropolitan Fire Service, the South Australian Country Fire Service and the Department of Environment and Heritage. Although some agencies may attend many types of fire incidents, and that data may have been supplied, this analysis exclusively refers to vegetation fires only, unless otherwise indicated.

For an explanation of the key terms, limitations and methodology refer to the introduction, glossary and methodology chapters.

Introduction

South Australia is the fourth largest of Australia's states and territories, covering a total area of 984,377 square km. It is located in the central south of mainland Australia, sharing borders with all other states and territories except Tasmania and the Australian Capital Territory.

Geography

The state is of generally low relief, with approximately 50 percent being less than 150 m above sea level, and 80 percent being less than 300 m. The River Murray, which drains one-seventh of Australia's landmass, enters the state on its eastern border, but falls less than 22 m in altitude in the 642 km before entering the Southern Ocean via the heavily silted river mouth at Lake Alexandrina and Lake Albert (Figure 1). The Mount Lofty–Flinders Range system is the most notable mountain range in South Australia, extending 800 km from Cape Jervis in the south to Lake Torrens in the north, but nowhere does the range exceed 1,200 m. In the western portion of the state the sparsely inhabited Nullarbor Plain directly fronts the cliffs of the Great Australian Bight. To the south lies Kangaroo Island, South Australia's most prominent island, at 4,350 square km.

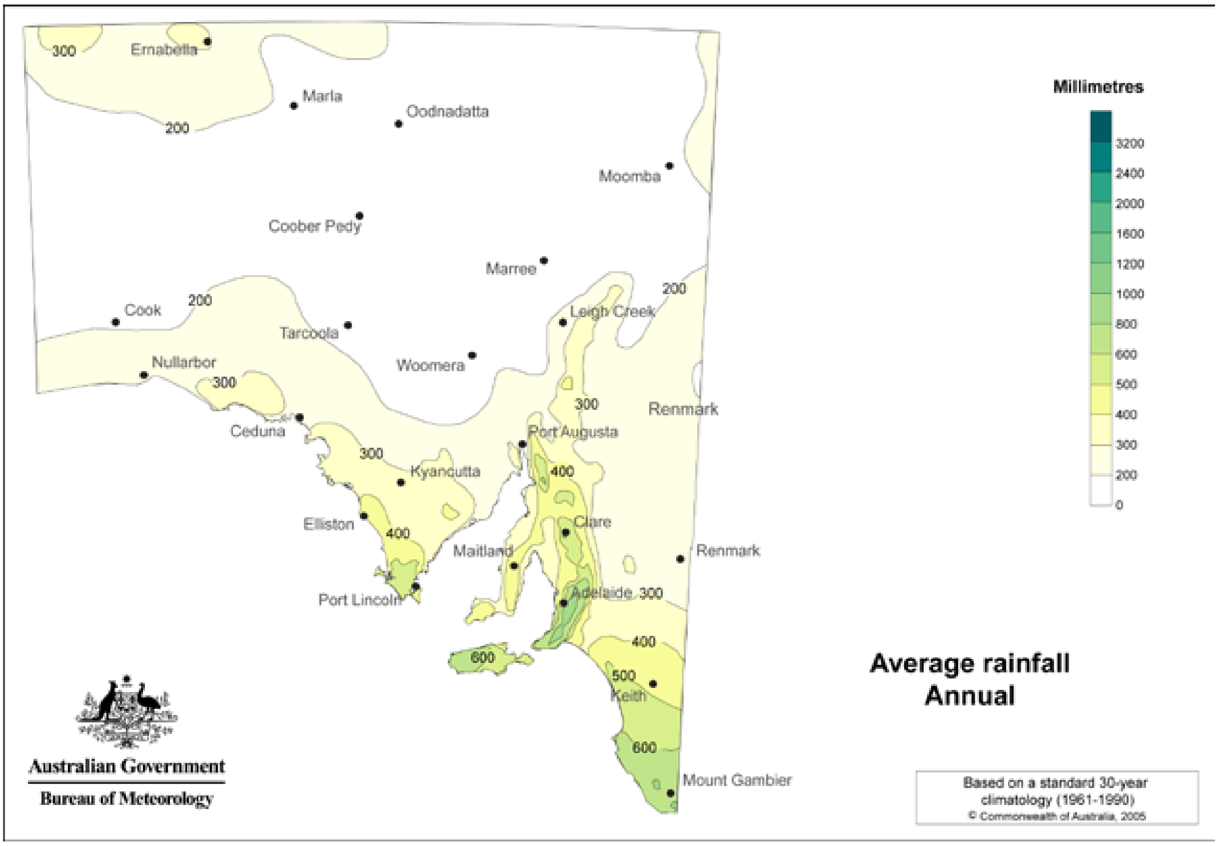
Figure 1: Map of South Australia

Climate

South Australia's climate is characterised by hot, dry summers with relatively mild nights, and cool but not severe winters. The average maximum temperature is 29°C in January and 15°C in July. Overall, the average maximum temperature increases northwards. In January, the average daily maximum ranges from 21°C to 24°C in the south to more than 36°C in the state's far north, but daily temperatures in parts of the state may be as high as 48°C (Australian Bureau of Meteorology, 2007a).

Overall, rainfall is low, with four-fifths of the state normally receiving less than 250 mm of rain annually. Most rainfall occurs during the late autumn and winter. The highest annual average rainfall typically occurs along the Flinders and Mount Lofty Ranges and near the southern coast, but drops to less than 250 mm within 150 to 250 km of the coast (Figure 2). Much of the inland areas are covered by featureless plains, or sand and gibber deserts (Australian Bureau of Meteorology, 2007b).

Figure 2: Average annual rainfall

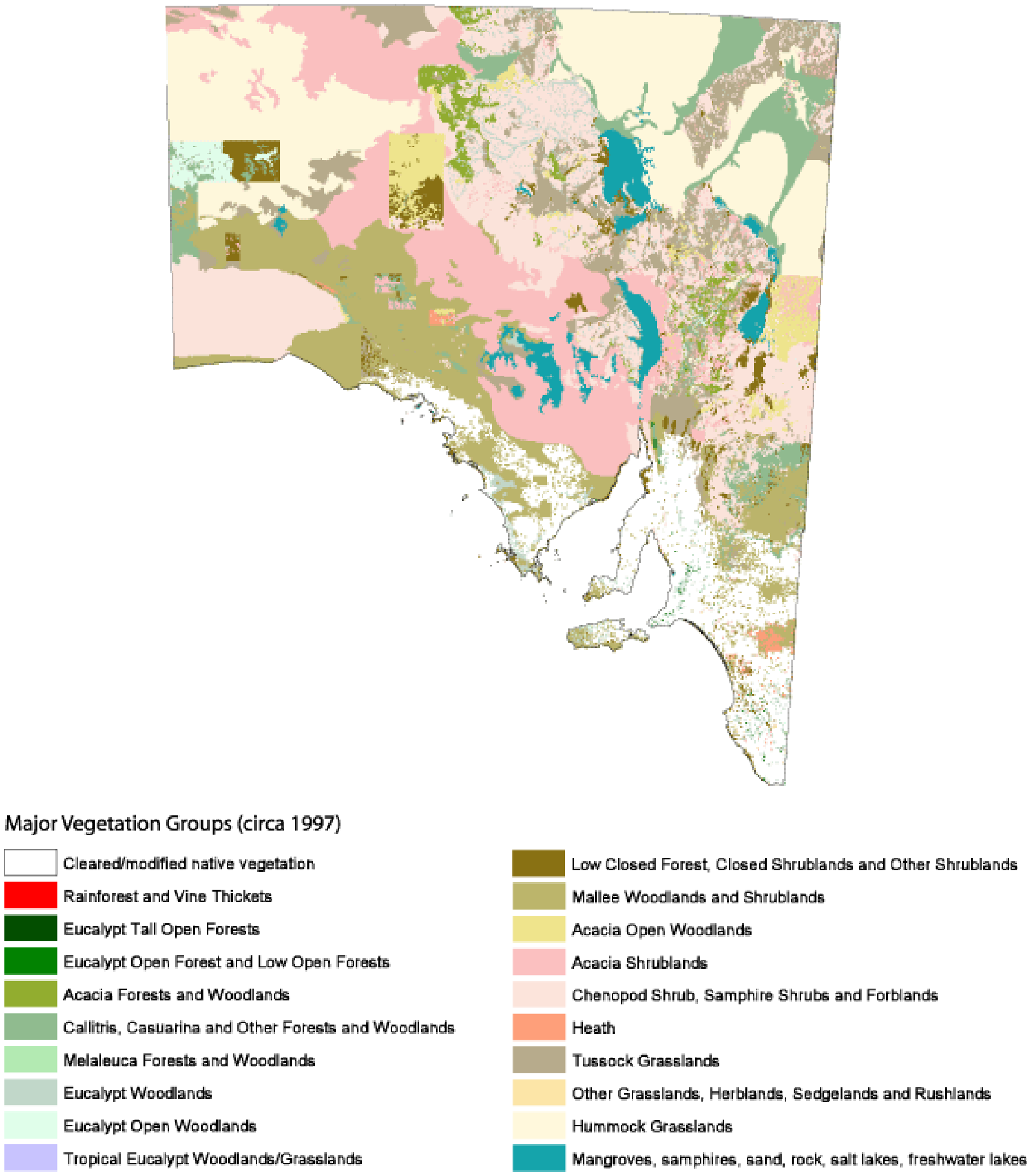


Source: Australian Bureau of Meteorology 2007b

Native vegetation

Extensive areas of mallee, chenopod (saltbush, bluebush), shrublands, acacia shrublands (mulga and myall) and hummock grasslands cover the arid and low rainfall portions of the state's north (Figure 3). Small areas of eucalypt open forest and woodland occur in the southeast of the state. However, little native vegetation remains in the wetter areas of state's southeast, owing to extensive clearing or modification for agricultural purposes (Australia. Department of Environment and Heritage 2001b).

Figure 3: Major vegetation groups (c. 1997)



Source: Australia. Department of Environment and Heritage 2001b

Land use

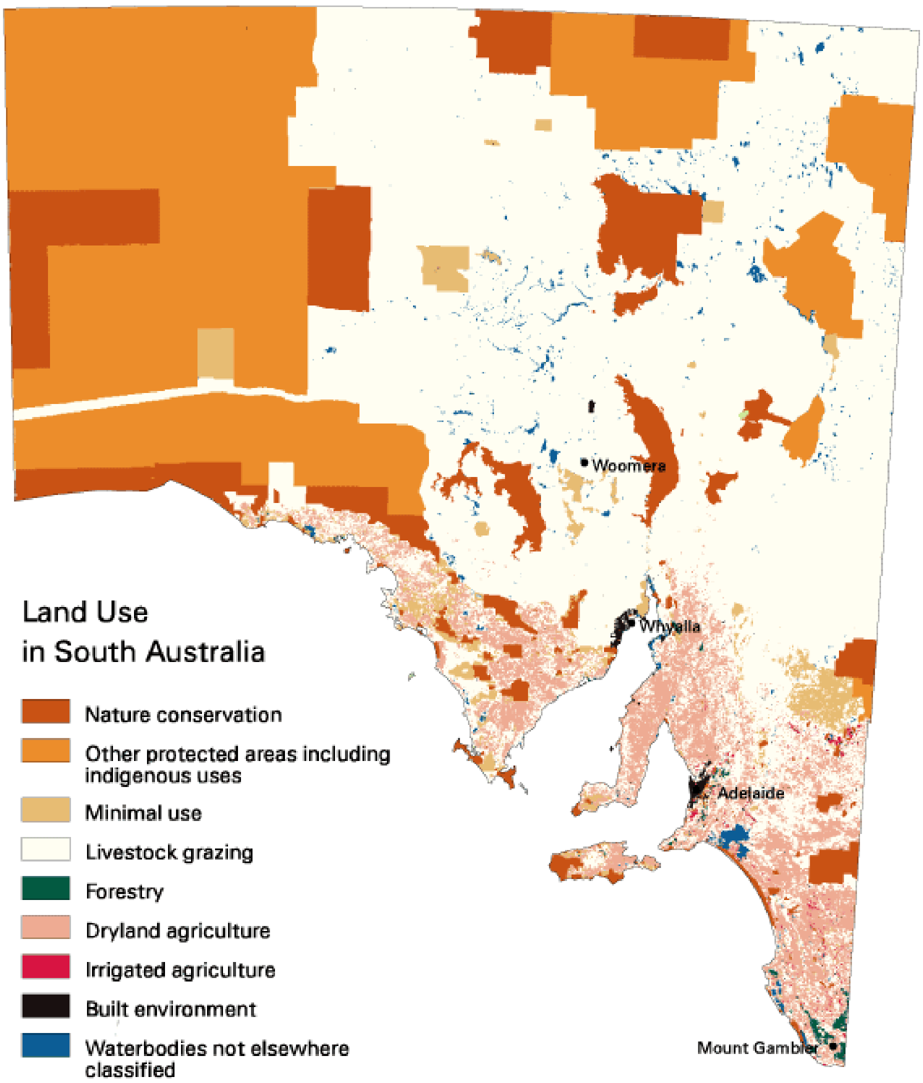
As of 1996–97, dryland agriculture occurred in six percent of the state, principally in the higher rainfall areas along the southeast coast (Figure 4). Small isolated pockets of irrigated agriculture occur along the Murray, but are less extensive than those occurring in New South Wales and Victoria. Cropping mostly includes cereal crops (wheat, barley and oats), but also oilseed and grain legume crops. Many types of temperate vegetables and orchard crops are grown in the Adelaide Hills, the northern Adelaide Plains, the southeast and the Riverland. Extensive vineyards, principally for winemaking occur throughout the Barossa and Clare Valleys, the Riverland, Southern Districts and Coonawarra.

In 1996–97 livestock grazing accounted for 51 percent of the state's area. Livestock are primarily sheep (commonly for wool production), but beef cattle are raised in the Adelaide Hills, the lower southeast and far north districts. Dairying principally occurs around Adelaide, and the lower southeast and lower Murray districts.

As of 1996–97, 28 percent of the state was retained for nature conservation. Just over half of this is in nature reserves. International Union for the Conservation of Nature and Natural Resources (IUCN) category wilderness areas and national parks collectively accounted for a further 36 percent of nature conservation in the state. 'Other protected areas including indigenous uses' cover 11 percent of the state. Areas retained for nature conservation occur throughout the state but large areas of the arid west and north fall within these categories.

Forestry is minor in South Australia owing to the low rainfall. Most forestry occurs in the moister areas around Mount Gambier in the State's southeast (Australia. Department of Environment and Heritage 2001a).

Figure 4: Land use (c. 1996–97)



Source: Australia. Department of Environment and Heritage 2001a

Population

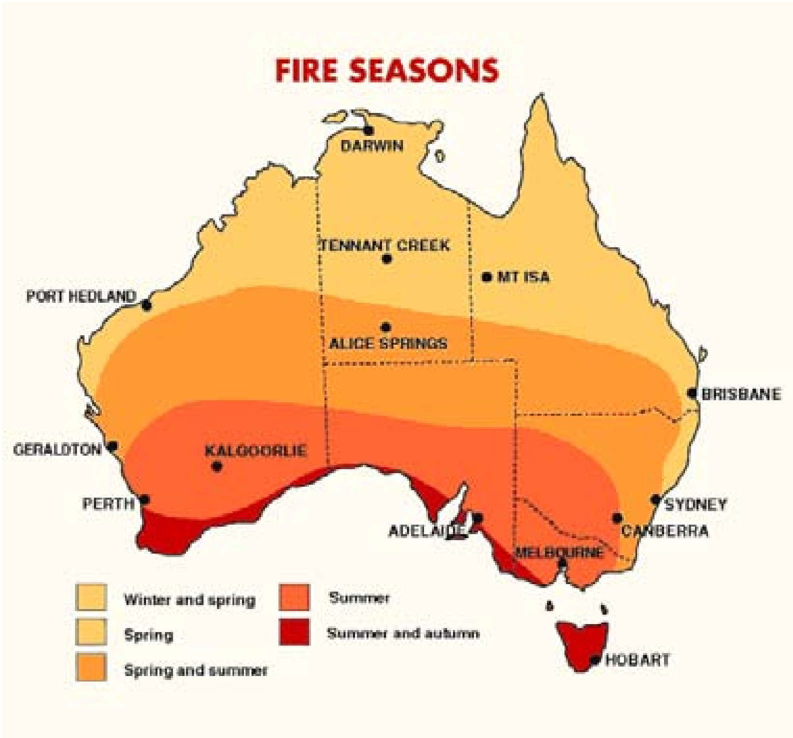
As of June 2006, the resident population of South Australia was 1,554,700, accounting for 7.5 percent of Australia's population (ABS 2006). Almost three-quarters of the state's population reside within the Adelaide statistical subdivision, with most of the remainder residing in the fertile region along the southeastern coast of the River Murray. Major regional urban centres include Mount Gambier, Port Pirie, Murray Bridge, Port Augusta and Whyalla.

As of June 2005 South Australia had the highest median age (the age at which half the population is older and half is younger) of all states and territories in Australia, at 38.8 years, compared to the national average of 36.6 years (ABS 2005a). Only 18.4 percent of the state's population was under 15 years of age, the lowest recorded by any state or territory. The highest proportion of children of this age occurred in the Eyre statistical subdivision, and in the local government areas of Roxby Downs, Anangu Pitjantjatjara, Ceduna and Playford.

Bushfire regimes

Severe bushfires are not uncommon in South Australia owing the hot dry conditions that characterise summer. Bushfires commonly occur from October through to May, but historically the most devastating have occurred in January and February. Some variation in fire regimes occurs northwards owing to lower and less reliable rainfall away from the coast (Figure 5). Fires shift from spring- and summer-dominant in the north of the state, to summer-dominant in the centre, through to summer- and autumn-dominant in the south (Eyre Peninsula and the far south east corner around Mount Gambier (Lindesay 2003).

Figure 5: Timing of bushfire seasons in Australia



Source: Australian Bureau of Meteorology 2007c

Bushfire history

South Australia has experienced a number of devastating bushfires. A compilation of the most significant bushfire events and seasons is outlined in Table 1; the fires during the 1939, 1955, 1983 and 2005 seasons discussed in greater detail below.

1939: Black Tuesday – 10 to 14 January – Exceptionally high temperatures (up to 46.1°C in Adelaide) and strong winds (up to 45 km per hour in Adelaide) fanned fires around Adelaide and the Mount Lofty Ranges (Adelaide Hills). Six thousand volunteers attempted to battle blazes with branches and wet bags as the fires that had originated near forested areas, subsequently spread into open farmlands. Firefighters, residents and property owners battled to save the townships of Mount Torrens, Macclesfield and Meadows. No lives were lost, but 90 houses and other building were destroyed in Crafers, Stirling and Upper Sturt and from Mount Osmond to Glen Osmond. The cost was estimated at £650,000. During the same period fires burned extensive areas of grassland and 1,000 hectares of pine forest were destroyed near Naracoorte, Penola and Mount Gambier, in the state's southeast, resulting in the death of one child (South Australia Central 2007).

1955: Black Sunday – 2 to 3 January – on a day with extreme temperatures (43°C in Adelaide at 1 pm), low humidity and strong winds (gusts of 100km per hour), 13 major fires broke out with multitudes of fires burning in the Adelaide Hills, Jamestown and Waterloo in the state's north, and Kingston and Millicent in the southeast. The fires resulted in the deaths of two firefighters, and £2 million (1955 values) damage to property including the governor's summer residence at Marble Hill. Source: CFS (2005b) and EMA (2006a)

1983: Ash Wednesday – 16 February – Fires sparked by exceptionally adverse bushfire weather broke out in both South Australia and Victoria. In South Australia, major fires burned to the west of Clare in the mid north, in at least four separate areas in the Mount Lofty Ranges, as well as in the lower southeast of the state. Fanned by strong winds, the fires burned about 1,600 square km, destroyed 385 houses, burned 10,000 km of farm fencing, and destroyed 500 vehicles and two timber mills. Three-quarters of the total area was burned in the southeast. Sixty percent of the houses lost were in the Mount Lofty Ranges. Twenty-eight people died, with a further 67 hospitalised. Livestock losses were estimated at between 257,000 and 300,000 head. Financial losses were estimated at $200 million to $400 million. Source: DSE 2007, EMA 2006b, South Australia Central 2007.

2005: Black Tuesday – 11 January – On a day where temperatures higher than 40°C were reached by 11 am and there were winds of more than 100 km per hour, 16 separate fires broke out across the state. The most devastating of these occurred at Wangarry on the Lower Eyre Peninsula. Fires rapidly spread, consuming 77,000 ha of land, and trapping people in their cars as they attempted to escape. Nine people died, including two firefighters. A further 110 people sustained injuries; at least 93 houses and 237 sheds were destroyed with damage to at least another 11 homes and numerous commercial properties. The Wangarry fire resulted in the loss of 46,780 head of livestock, and 6,300 km of fencing. Emergency Management Australia estimated the insurance cost at $27,700,000, but the Country Fire Service indicated the total cost was likely to exceed $100,000,000 (CFS 2005a; 2005b).

Table 1: Bushfire history of South Australia

Date	No. of deaths	Area of fire (ha)	Losses	Location(s)
1938–39a	1		90 houses and numerous other buildings; £650,000	Adelaide Hills; Naracoorte, Penola Mount Gambier
1943–44				Adelaide Hills
1948–49	1			Bridgewater, Gawler, One Tree Hill, Mount Barker, near Wilmington, Port Lincoln
1950				Mount Lofty and grass fire north of Morgan and east of Burra
1951 December	5 fire fighters	450,000	Stock, feed, fencing	Adelaide Hills, Woodside, Stirling, Lenswood, and districts in the southeast
1954–55 January	2 fire fighters	>40,000	Houses, timber	Mount Lofty Ranges
1957–58 January	8 fire fighters	1,370	413 ha of pine forest	Mount Gambier
1959	1	104,000	$1,500,000	Kongorong, Wudinna
1960		114,000	'Lots of damage'	Northern part of Yorke Peninsula, Wirrabara, Tintinara
1961				Wilpena Pound
1968–69		900,000	Feed, stock, fences	West of far north region, Murdinga
1974–75		16,000,000		North-west of state (arid and semi-arid zones)
1980			35 houses; $6 million	Adelaide Hills
1983	28	160,000	383 homes, forest plantations, conservation parks, >200 buildings	Mount Osmond, Mount Gambier, South Barwon
1985				Adelaide Hills
1998				Flinders Ranges (70% of Wilpena Pound burned)
2001			Approx. 20 buildings	Tulka
2005b	9	77,132	More than 93 houses; 11 homes damaged; numerous other buildings; 46,780 livestock lost; 6,300 km of fencing; Cost of probably more than $100,000,000	Lower Eyre Peninsula; Mount Osmond

a: data from South Australia Central 2007

b: data from CFS 2005a; 2005b

Source: Modified from Ellis, Kanowski & Whelan 2004

Fire services

Four major agencies provide fire services in South Australia. They are the South Australian Metropolitan Fire Service, the South Australian Country Fire Service, the SA Department of Environment and Heritage and Forestry SA.

The **South Australian Metropolitan Fire Service** (SAMFS) provides a broad range of emergency services – fires, road crash rescue, gas leaks, chemical spills, rescues, structural collapse, animal rescue, storm damage, lockouts, flooding, and smoke alarms and private alarms – to approximately 95 percent of the state's population. As of 2002–03 the SAMFS comprised 782 permanent and 236 retained firefighters working from 35 fire stations. For further information see http://www.samfs.sa.gov.au.

The **South Australian Country Fire Service** (SACFS) is a community-based fire and emergency service that operates in rural and semi-urban South Australia. It is staffed by 85 full-time equivalent employees and over 15,500 volunteers, with 434 brigades. The SACFS attends bushfires, hazardous material spills (specialised service), structural and motor vehicle fires, and provides fire protection at road crashes and performs road crash rescue. The SACFS also provides support for the SAMFS and assists local government in fuel removal and bushfire prevention and in community and fire safety investigation (CFS 2005c).

The **South Australian Department of Environment and Heritage** (SADEH) is responsible for on-the-ground management of the state's public land – including land held in the conservation reserve system and as Crown lands. This incorporates approximately 330 reserves that cover 21.7 percent of the state. The department is responsible for protecting life, property and biodiversity values, and helps the SACFS minimise the risk associated with fire in natural bushland. For further information see http://www.environment.sa.gov.au.

Forestry SA manages 125,000 hectares of state-owned forest resources in South Australia. This consists primarily of softwood plantation but also includes 23,900 ha of Native Forest Reserves for nature conservation. Forestry SA lands are principally located in the Green Triangle Region (southeast coastal region), the Mount Lofty Ranges and the Mid North Regions. For further information see http://www.forestry.sa.gov.au.

The SAMFS and SACFS, together with the SA State Emergency Services, are members of the South Australian Fire and Emergency Services Commission, a government organisation established to improve communication and coordination across the various emergency service sectors. For further information see http://www.safecom.sa.gov.au/.

The South Australia analysis is based on data provided by the Metropolitan Fire Service, Country Fire Service and the SA Department of Environment and Heritage only.

South Australian Metropolitan Fire Service analysis

Background about the SAMFS dataset and its analysis

Important information regarding the SAMFS dataset and the methodology employed to analyse it is outlined below.

- The data were sourced from the South Australian Metropolitan Fire Service (SAMFS).
- The SAMFS analysis differs fundamentally from that conducted for other agencies as it does not represent an analysis of all vegetation fires; rather the database provided only included those vegetation fires were the activity in the area was identified as malicious (hereafter referred to as malicious vegetation fires).
- The database used the Australian Incident Reporting System (AIRS) classification codes
- The database supplied included both malicious vegetation and rubbish fires; vegetation (AIRS wildfires = Type of Incident code 160 to 179) fires were extracted from this dataset.
- In rare instances, the analysis draws on the combined 'grass [vegetation] and rubbish' fire data, from SAMFS annual reports and the dataset provided, as this is the only means to make very rough estimates about the total number of vegetation fires and the proportion of deliberate vegetation fires the SAMFS attended, and thereby provide a comparison for other South Australian and Australian fire agencies.
- The database includes data from 1997–98 to 2005–06; although the data for 1998–99 to 2000–01 are variably incomplete due to industrial actions (see Methodology chapter).

- Information pertaining to form of heat of ignition and ignition was supplied.
- For the purpose of the SAMFS, all cases in the database, that is, all vegetation fires where the activity in the area was classified as malicious were said to be deliberate. This differs fundamentally to the analysis conducted for other agencies that use AIRS database codes, where the cause of the fires is defined on the basis of the ignition factor codes; the two systems do not directly correspond; not all fires classified as having malicious activity are classified as incendiary or suspicious or vice versa (see Methodology and the Victorian Country Fire Authority analysis, the Victoria chapter.
- Includes information pertaining to the type of incident.
- Smoking-related fires were classified on the basis of 'form of heat of ignition'='heat from smokers' materials' (AIRS form of heat of ignition codes 300 to 390).
- The interpretation of child fires is complex and does not represent a complete analysis of vegetation fires started by children in urban South Australia. Notably, the database only included fires where the ignition factor code was identified as children playing, and where the activity in the area was identified as malicious. This is likely a very small subset, as in many cases, fires started by children where the activity in the area was deemed malicious, would be classified simply as incendiary or suspicious within the ignition factor code (as per AFAC (AIRS) guidelines). Moreover, the analysis will not include any accidental fires started by children, where the activity in the area was not malicious.
- The definition of regions used in the SAMFS analysis is based on tourism regions as defined by the Australian Bureau of Statistics (ABS 2005b) for South Australia. Assignation to a tourism region was based on the postcode, which was derived from the suburb name provided. There is not an exact concordance between the postcode and tourism regions. The ABS defines tourism region based on smaller statistical areas so ABS tourism regions potentially crosscut suburbs and postcodes. In this study, assignation was based on the highest levels of concordance between postcodes and tourism regions. Hence, there is not an exact correspondence between tourism regions used in this analysis and ABS tourism regions.
- A rough estimate of the breakdown of the type of property was made based on the information provided within the 'premises' variable supplied. The categories defined included education, business, reserve/park, recreation/sport complex, vacant/Crown land, mass transport, road complex, scrub/grassland, walkway/bike path, residential, near non-marine water, other open space, beach/marine/wharf, community centre, hotel, other organisation, medical centre/hospital, religious facility, government organisation, other community facility, child care, dump/rubbish, aged care, cemetery, construction/demolition, correctional facilities, and unknown. Note however, information about the type of premises was only available in 31 percent of cases.
- The dataset does not include area burned; this would typically have been small. There is only one forest or woods fire recorded as having burned more than 1 ha, but there may have been grass fires than burned similar area.

For more detail about these methodologies see the Methodology chapter.

Overview

Fires attended by the SAMFS can be summarised as follows.

- SAMFS records indicate that between 1997–98 and 2005–06 the service attended 2,926 vegetation fires where the activity in the area was identified as malicious. This figure represents a minimum value as the records were affected by industrial action.

- It is impossible, based on the data provided and the available published information, to ascertain the exact number of vegetation fires the SAMFS attended in any one year. Based on the information presented in annual reports, the SAMFS attended between 2,347 and 2,925 ‘grass and rubbish’ fires (only combined information is available; Figure 6). In this usage the term grass is used loosely, being equivalent to the term wildfire (AIRS codes), landscape fire (Australian Productivity Commission) or vegetation fire (this study). Unfortunately, there is insufficient information to determine what proportion of all ‘grass and rubbish fires’ were actually vegetation fires. If it is assumed that the ratio of malicious vegetation fires to malicious rubbish fires (information provided) accurately reflects the ratio of vegetation fires to rubbish fires generally in a given year, it is likely that SAMFS attended somewhere between 800 and 1,800 vegetation fires in any given year.
- The SAMFS is an urban service, and the types of vegetation fires attended reflect that environment. The principal types of fires attended were small vegetation/grass fires, with only one fire occurring in forest/woods (greater than 1 ha), and 1.8 percent occurring in mixed scrub, bush, grass settings. Vegetation fires in urban environments may include fires in the local park or reserve, but will also include fires along road verges, in access ways, as well as hedge fires, single tree/bush fires, fires on the local oval etc. It is unclear to what extent the SAMFS may attend the same incidents as the SACFS and SADEH. Overall, the number of fires that were or had the potential to be bushfires is likely to be comparatively low.
- It is impossible, on the basis of the data provided, to ascertain the percentage of vegetation fires that were likely to have been deliberately lit, but the value is likely to have been somewhere between 15 percent and 30 percent.

Cause

The actual number of malicious vegetation fires attended ranged between a low of 165 in 1998–99 and a high of 436 in 2001–02 (Figure 6). The average number attended was 325 (SD=90).

As the exact number of vegetation fires the SAMFS attended in any one year is unclear, it is difficult to ascertain the proportion of those fires that may have been associated with malicious activity. Nevertheless, some broad estimates can be made based using the rough numbers of vegetation fires (all causes) calculated above. Using this ‘broad-brush’ approach it is estimated that somewhere between 15 and 30 percent of vegetation fires the SAMFS attended were associated with malicious activity (Figure 6), a figure that is broadly consistent with the proportion of deliberate vegetation fires the SACFS attended.

Specific ignition factors

Form of heat of ignition: Almost 60 percent of malicious vegetation fires resulted from an open flame or spark (Figure 7). Twenty-six percent involved a hostile fire, 6.6 percent a fuel-powered object and 1.4 percent explosives or fireworks (Figure 7). There were 16 recorded instances where incendiary devices were used. A match was the factor most frequently recorded within the open-flame category (approximately 50%), followed by other factors, and lighters (Figure 8).

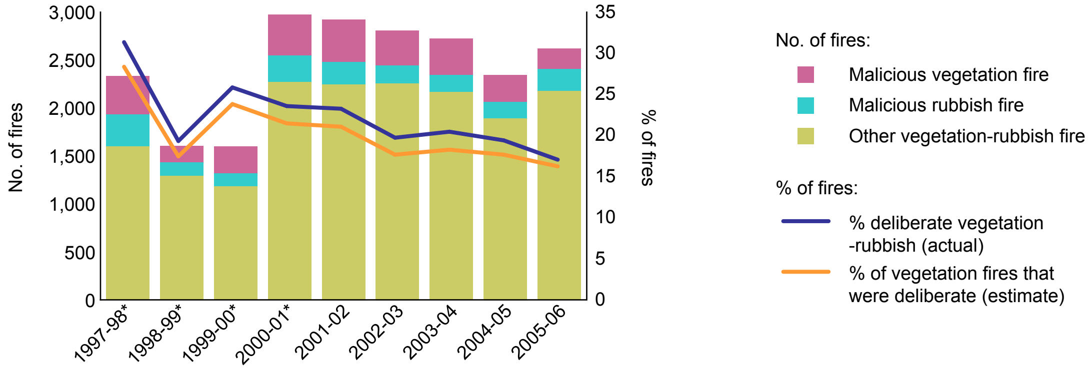
Overall, the proportion of fires relating to each category remained stable over the observation period. The notable exception was in the increased number and proportion of vegetation fires attributed to fuel-powered objects since 2000–01 (Figure 9).

Fires started by children: There were 137 instances where malicious activity was combined with a ‘children playing’ category in the ignition factor code. This represents 4.7 percent of all malicious vegetation fires. This does not represent all incidents where a child was responsible for a fire, as this dataset only comprises fires where the activity in the area was malicious. Nor does it include all cases where the child was responsible for a malicious fire that was categorised as incendiary or suspicious in the AIRS ignition factor codes, where there would be no indication that a child lit the fire.

In most instances the age of the child was unknown. Notably, there were only four malicious fires for which the age of the child was assigned. All were in the 6- to 12-year-old group.

Smoking-related vegetation fires: Two percent (n=57) of all malicious vegetation fires the SAMFS attended were smoking-related, ranging between one and three percent in any one year. Although the proportion of smoking-related fires was in the realm of values observed for many other, particularly regionally based, fire agencies, it is highly probable that these figures do not in any way accurately reflect either the incidence or proportion of smoking-related vegetation fires the SAMFS attended. Notably, for most agencies, the overwhelming majority of smoking-related fires are not considered incendiary or suspicious, and hence are much less likely to appear in this dataset, which only refers to fires where this was malicious activity in the area.

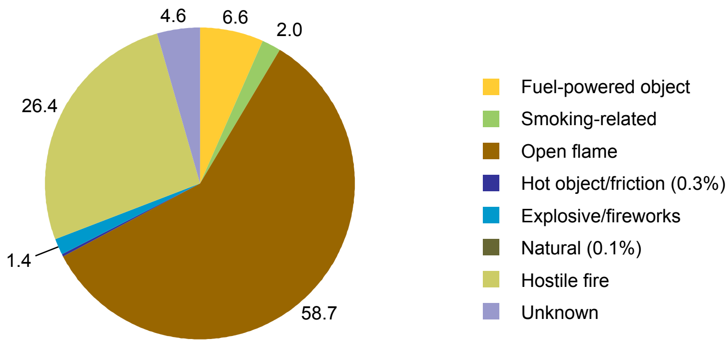
Figure 6: Cause of malicious fires by year[a]



Source: SAMFS 1997–98 to 2005–06 [computer file]; SAMFS, published (annual reports; references) and unpublished (pers. comm.) data

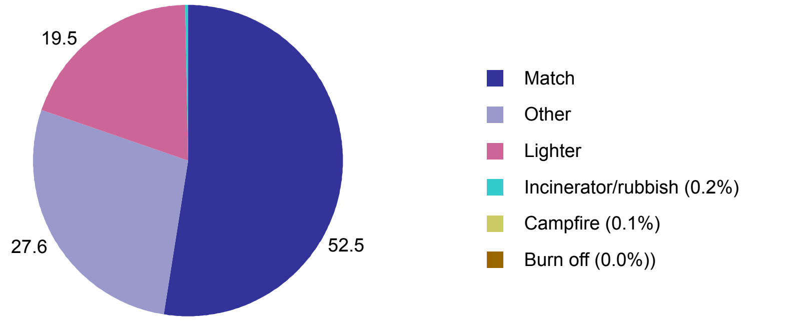
a: asterisk indicates years affected by industrial action

Figure 7: Form of heat of ignition (percent)



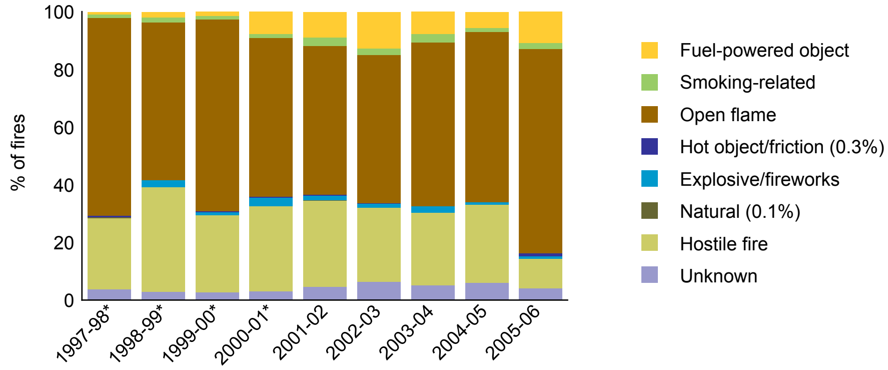
Source: SAMFS 1997–98 to 2005–06 [computer file]

Figure 8: Form of heat of ignition for fires within the 'open flame-spark' category



Source: SAMFS 1997–98 to 2005–06 [computer file]

Figure 9: Form of heat of ignition by year



Source: SAMFS 1997–98 to 2005–06 [computer file]

Location

Information about the location of fires includes the regional distribution of fires as well as details about the type of complexes where fires occurred.

Region

The fire data have been classified according to 2005 ABS tourism regions (Figure 10). Approximately 83 percent of all SAMFS malicious vegetation fires from 1997–98 to 2005–06 occurred in the Adelaide region (Figure 11); followed by Flinders Ranges (9.6%), Eyre Peninsula (4.3%), Riverland (1.9%) and Limestone Coast (0.6%).

This analysis also used combined vegetation and rubbish fire (rubbish – vegetation fires) data from SAMFS annual reports to enable a more detailed analysis of fire distributions. A more detailed analysis for 1999–2000 to 2002–03 from SAMFS annual reports, combined with the causal data supplied for malicious vegetation and rubbish fires reveals marked variations in the number and cause of vegetation fires between stations. (Note: 1999–2000 to 2002–03 was the only period for which detailed information was available in online annual reports at the time of analysis). Within the Adelaide region, the Elizabeth and Salisbury stations attended the greatest number of vegetation fires, followed by Christie Downs, Oakden, Adelaide and O'Halloran Hill (Figure 12). The highest number of rubbish – vegetation fires in regional South Australia from 1999–2000 to 2002–03 occurred in the large urban centres of Port Augusta, Whyalla and Port Pirie (Figure 12).

Overall, there was a strong correspondence between the total number of rubbish – vegetation fires attended by stations and the number of such fires associated with malicious activity ($r=.95$; $p<.001$; for all South Australian urban fire stations), for the period 1999–2000 to 2002–03. Hence, it is not surprising that in the Adelaide region, the Salisbury and Elizabeth stations attended the greatest number of malicious rubbish – vegetation fires (combined) (Figure 12). Other stations to record high numbers of malicious rubbish – vegetation fires included Christie Downs, O'Halloran Hill and Angle Park. For these stations, 26 to 34 percent of all rubbish – vegetation fires were associated with malicious activity. This contrasts with values of the eight to 10 percent in Ridgehaven, Prospect and Adelaide stations.

The number of malicious rubbish – vegetation fires in regional South Australia was comparatively smaller than for metropolitan Adelaide brigades. The greatest number of malicious rubbish – vegetation fires were recorded for the Port Augusta (n=132), Port Pirie (n=72) and Whyalla (n=70) stations (Figure 12). In Port Augusta and Port Pirie 54 and 46 percent of all rubbish – vegetation fires were associated with malicious activity, whereas in Whyalla, Port Lincoln and Mount Gambier the value was 16 to 23 percent.

The proportion of all malicious rubbish – vegetation fires that were actually vegetation fires was typically greater than 50 percent, but varied quite markedly between stations (Figure 12). Three stations that reported a high number of rubbish – vegetation fires – Elizabeth, Salisbury and Christie Downs – were characterised by a higher proportion of malicious vegetation fires relative to malicious rubbish fires when compared with other metropolitan Adelaide stations. The proportion of vegetation fires, as opposed to rubbish fires, within the malicious category varied even more markedly for regional stations.

The number of malicious rubbish – vegetation fires that occurred in the Adelaide region decreased in between 2001–02 and 2005–06 (Figure 13). In contrast the number of malicious rubbish – vegetation fires in most non-metropolitan regions remained stable over the same period. Hence, the Adelaide region contributed lower proportions of malicious vegetation fires as progressed.

In relation to specific ignition factors:

- Five of the 16 instances were an incendiary devices was used occurred in the Elizabeth area, with a further four fires each being recorded by the Ridgehaven and Christie Downs stations.
- There has been an increase in the number and proportion of malicious fires associated with fuel-powered machines since 2000–01. This principally reflects increased numbers of such fires in the Salisbury–Elizabeth area.
- 97 percent of all cases where child-lit fires were documented as having been associated with malicious activity occurred in the Adelaide region.
- Smoking-related fires accounted for the highest proportion of all malicious vegetation fires the Adelaide and Gawler (11%) and Angle Park (6.7%) brigades attended, although overall frequencies were very low.

Complex

Information about the type of premises at which fire occurred was available for 31 percent of malicious vegetation fires between 1997–98 and 2005–06. Of these, fires most typically occurred in reserves or parks (20% of where the premises was known) and at educational institutions (19% of known premises), followed by vacant or Crown land (11% of known premises) and on scrub/grassland (10% of known premises; Figure 14). Although some caution is needed in extrapolating these results to malicious vegetation fires generally, they are broadly consistent with trends described elsewhere.

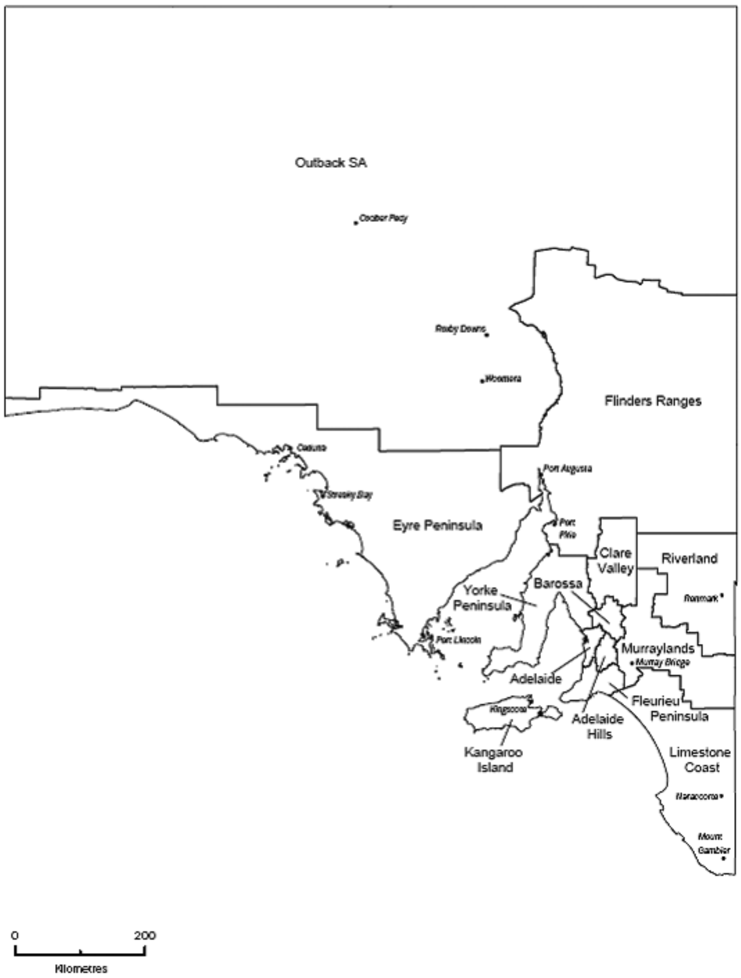
Educational institutions: There were at least 171 instances where malicious vegetation fires occurred at an educational institution, representing 19 percent of all cases where the type of premises was identified for malicious vegetation fires. Approximately 80 percent of these occurred at educational institutions in the Adelaide region, with a further 11 percent in the Flinders Ranges region (Port Augusta and Port Pirie stations), and five percent in the Eyre Peninsula region (Whyalla and Port Lincoln; Figure 15). This regional distribution is comparable with the general distribution of malicious vegetation fires.

Fifty-seven percent of all malicious vegetation fires at educational institutions (where identified) occurred at primary schools, with a further 25 percent of fires occurring at high schools (Figure 16). The frequency of vegetation fires at tertiary educational institutions was very small, as were the number of vegetation fires occurring at kindergartens and preschools.

Some school grounds were clearly the sites of malicious vegetation fires more frequently than others. A cursory examination of the data indicates a high frequency of vegetation fires within the general vicinity of such schools (for example, on the same street). In these instances vegetation fires on school grounds may be a subset of malicious fires that occurred within the neighbourhood, rather than educational institutions being the specific target.

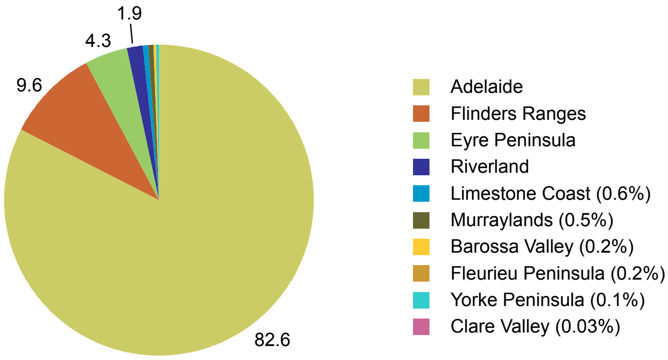
Business premises: Approximately, four percent of malicious vegetation fires (n=37), where the type of premises was identified, occurred at or near a business. Of these, approximately 14 percent occurred at a supermarket or shopping complex, 11 percent were at restaurants or takeaways, and three percent (n=1) were at petrol stations.

Figure 10: Australian Bureau of Statistics tourism regions of South Australia, 2005



Source: ABS 2005b

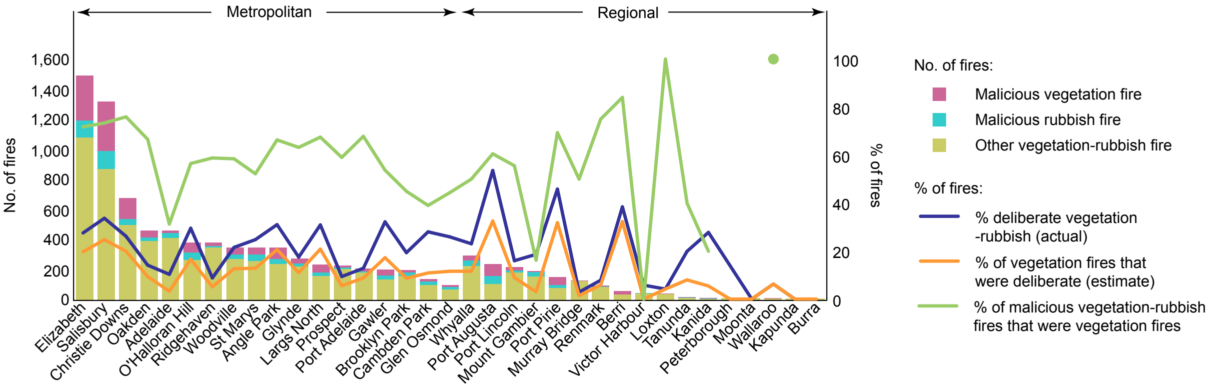
Figure 11: Malicious vegetation fires by region[a] (percent)



a: Fire stations included within each region are: Adelaide (Adelaide, Glynde, Woodville, Port Adelaide, Largs North, Oakden, Ridgehaven, Salisbury, Elizabeth, Gawler, Angle Park, Prospect, St Mary, Camden Park, O'Halloran Hill, Christie Downs, Glen Osmond, and Brooklyn Park stations), and regional urban centres in the Flinders Ranges (Port Augusta, Port Pirie), Eyre Peninsula (Whyalla, Port Lincoln), Riverland (Berri, Renmark, Loxton), Limestone Coast (Mount Gambier), Murraylands (Murray Bridge), Barossa Valley (Tanunda, Kapunda), Clare Valley (Burra), Fleurieu Peninsula (Victor Harbor), and Yorke Peninsula (Kanida, Wallaroo, Moonta)

Source: SAMFS 1997–98 to 2005–06 [computer file]

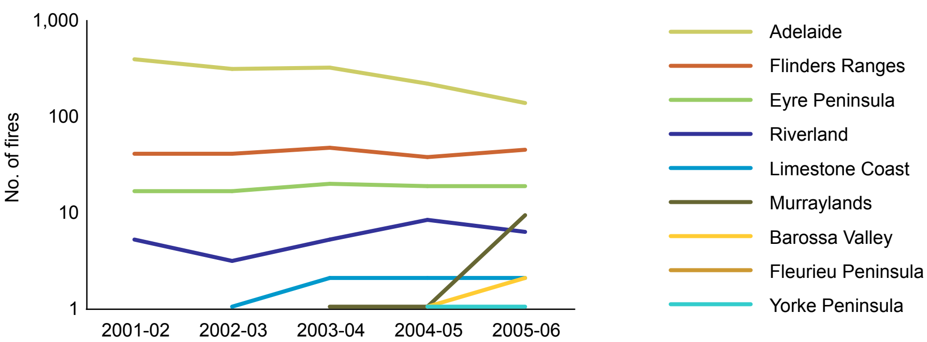
Figure 12: Malicious and non-malicious rubbish–vegetation fires[a] attended by station



a: Also shown is the proportion of all rubbish–vegetation fires that were malicious (% malicious (vegetation + rubbish); the percentage of all rubbish–vegetation fires that were malicious vegetation fires (% malicious vegetation); and the percentage of all malicious fires that were vegetation fires (% vegetation)

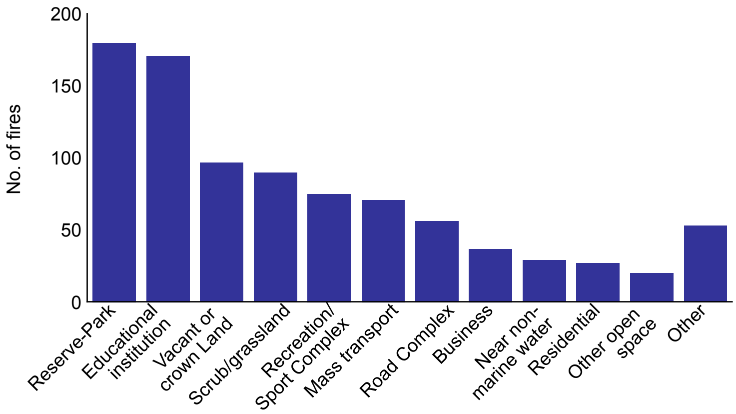
Source: SAMFS 1997–98 to 2005–06 [computer file]

Figure 13: Malicious vegetation fires in each region by year



Source: SAMFS 1997–98 to 2005–06 [computer file]

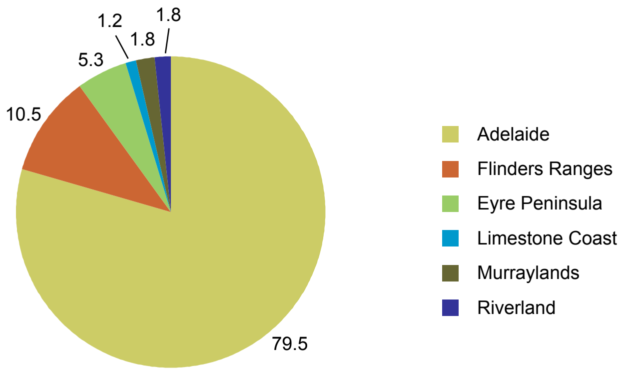
Figure 14: Malicious vegetation fires by premises type[a]



a: premises type known for 31 percent of malicious vegetation fires

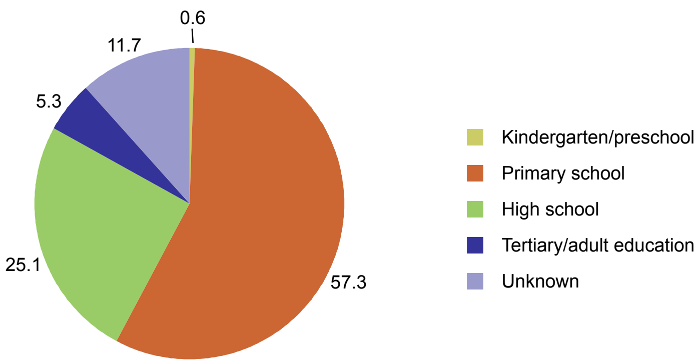
Source: SAMFS 1997–98 to 2005–06 [computer file]

Figure 15: Malicious vegetation fires at educational institutions by region (percent)



Source: SAMFS 1997–98 to 2005–06 [computer file]

Figure 16: Malicious vegetation fires by type of educational institution (percent)



Source: SAMFS 1997–98 to 2005–06 [computer file]

Timing

The timing of fires is examined by week of the year, day of the week and time of the day.

Week of the year

The majority of malicious vegetation fires occurred between week 44 (early November) and week 15 (mid April), the interval of greatest bushfire danger. However, detailed analysis shows the observed pattern varied between years (Figure 17):

- In 2001–02, there was a large spike in activity between weeks 47 and 52 (late November and December).
- In 2002–03, increased frequencies occurred in late August, coincident with the dry winter and spring in that year.
- In 2003–04, fires extended into late April; coincident with an absence of late summer early autumn rains.
- In 2004–05 and 2005–06 there were two concentrated spikes in fires, eight to ten weeks apart in late spring and summer.

Overall, there was a strong link between rainfall and the timing of fires.

Malicious vegetation fires at educational institutions occurred throughout the year. However, the greatest number coincided with the bushfire danger season, from week 46 (mid November) to week 12 (mid to late March; Figure 18).

Day of the week

There was a much greater propensity for vegetation fires to occur on weekends in urban South Australia than during the week. Approximately 1.4 to 1.5 times more malicious vegetation fires occurred on Sunday and Saturday respectively than on the average weekday. However, the proportion of fires that occurred on weekends varied between regions. In the Adelaide region, 1.36 and 1.41 times more malicious fires occurred on Sunday and Saturday respectively than on the average weekday (Figure 19). This was lower than the state average. In the Flinders Ranges (Port Augusta and Port Pirie), malicious vegetation fires were 1.7 and 2.2 more likely on Sunday and Saturday, respectively. Similarly, fires in the Eyre Peninsula region (Port Lincoln and Whyalla) were 2.7 and 2.5 times more likely to occur on Sunday and Saturday than on a weekday (Figure 19).

The overwhelming majority of malicious vegetation fires at educational institutions occurred outside of school hours, being 1.6 times more likely to occur on Sunday and 2.2 times more likely to occur on Saturday than on a weekday (Figure 20). Malicious vegetation fires were also three times more likely to occur at businesses on Sunday than on a weekday (Figure 20), but the number of fires on Saturday was significantly different. Note: the overall number of fires at businesses is small, and may not be genuinely representative of malicious vegetation fires at businesses generally.

Time of the day

The time a malicious vegetation fire occurred was recorded in approximately 60 percent of cases. The available data define two overlapping peaks; one during the afternoon and one at night. Combining these frequency distributions yields two maximums; at 5 pm to 6 pm and 10 pm to 11 pm (Figure 21).

A high proportion of all malicious vegetation fires in the Adelaide region were lit outside normal business hours, with 54 percent of cases where the time was known occurring between 6 pm and 6 am (night fires). The extent of night fires was variable at a local scale. For most stations, between 50 percent and 70 percent of all malicious vegetation fires occurred between 6 pm and 6 am. However, values as high as 74 percent to 75 percent were observed for the Glynde and Brooklyn Park stations and as low as 36 and 47 for the Gawler and Prospect stations.

Although ‘nighttime’ fires were a feature of most days of the week in the Adelaide region, a greater numbers of fires occurred on Friday night – Saturday morning and Saturday night – Sunday morning (Figure 22). This was most evident for the interval between midnight and 6 am. Approximately, 26 percent of all malicious vegetation fires on Saturday and Sunday occurred between midnight and 6 am, whereas only 14 percent and 19 percent (average of 17%) occurred during these times on weekdays.

The proportion of fires occurring within the midnight to 6 am window varied between stations. Typically, 20 to 35 percent of all malicious vegetation fires (where time was recorded) attended by each station occurred between midnight and 6 am, but for Brooklyn Park and Glen Osmond the values were 42 percent and 40 percent, respectively. Although Salisbury and Elizabeth recorded more malicious vegetation fires at night than any other station the proportion of fires that occurred from midnight to 6 am was comparatively low, at 16 percent to 17 percent (Figure 23). The Adelaide and Largs North stations also attended comparatively few malicious vegetation fires during the early morning hours before 6 am.

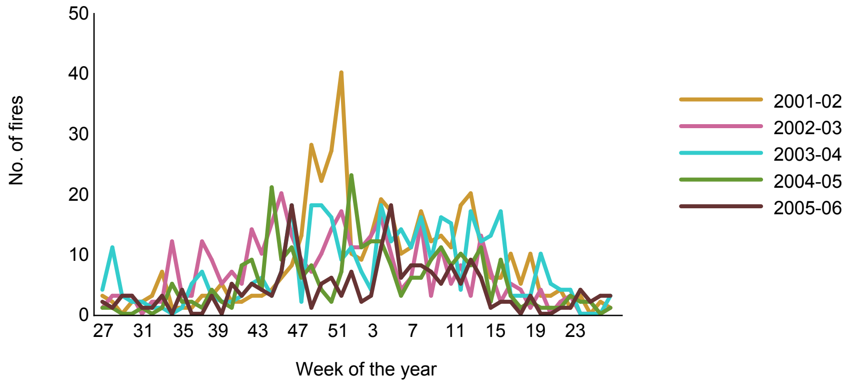
A high number and proportion of fires in major regional urban centres also occurred at night. Between 48 percent and 54 percent of all vegetation fires in the Flinders Ranges, Eyre Peninsula and Riverland regions occurred between 6 pm and 6 am (Figure 24). Approximately 14 to 20 percent of all malicious vegetation fires in these regions (where time was recorded) occurred between midnight and 6 am. This is similar to the values documented for metropolitan stations.

The time at which malicious vegetation fires occurred at educational institutions paralleled that recorded for malicious vegetation fires generally. High numbers of vegetation fires occurred between 3 pm and 6 pm (although in many cases this was on weekends rather than weekdays). However, approximately 60 percent (where time was recorded) of malicious vegetation fires at educational institutions occurred between the hours of 6 pm and 8 am (Figure 25). There was a spike in the number of fires at around 3 to 4 pm, but 19 out of the 25 fires that occurred between 2 pm and 6 pm were on weekends, not on school days.

The combined temporal data suggest that most malicious vegetation fires that occur at educational institutions occur outside normal school hours, including the period in which one might expect children to be making their way home. The timing of fires at educational institutions implies that many malicious vegetation fires occurred when a person visited the school out of hours (school holidays, weekends and at night), rather than by students committing the offence en route to or from school. A high proportion of fires occurred at primary schools so children attending those schools cannot be discounted, however, the timing of many of those fires implies that the people lighting the fires may have been older than primary school age (6–12 years).

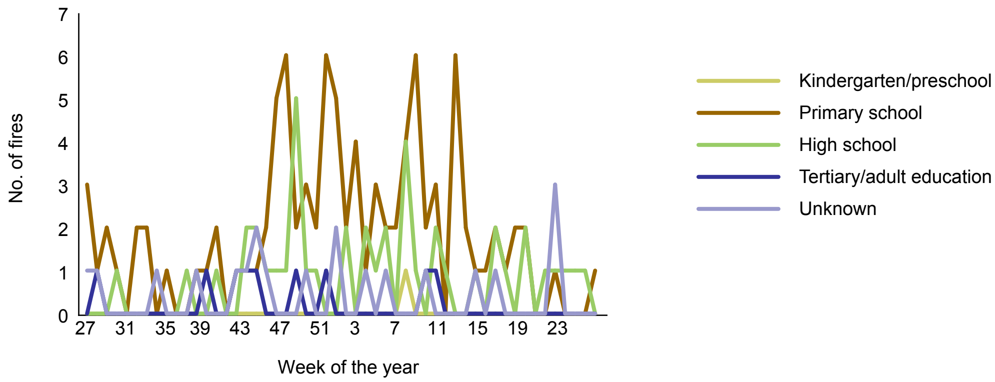
There was also a high propensity for malicious vegetation fires at businesses to occur during the night (Figure 25). However, given the low number of cases where the time was known this might not be representative of such fires generally.

Figure 17: Fires each year by week of the year



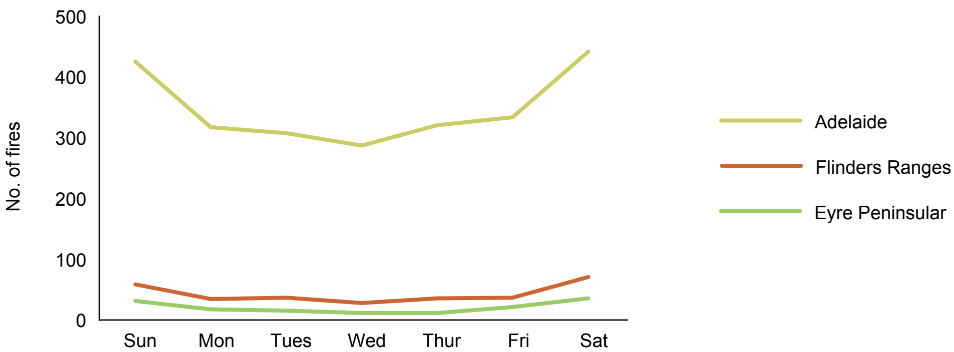
Source: SAMFS 1997–98 to 2005–06 [computer file]

Figure 18: Vegetation fires at educational institutions by week of the year



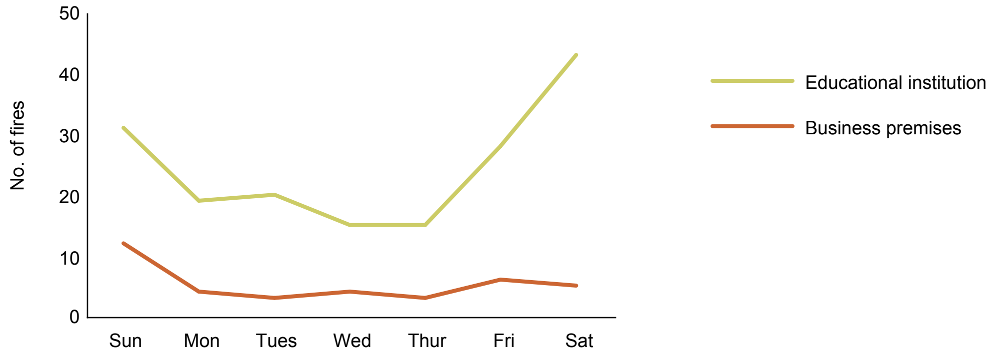
Source: SAMFS 1997–98 to 2005–06 [computer file]

Figure 19: Malicious vegetation fires in selected regions by day of the week



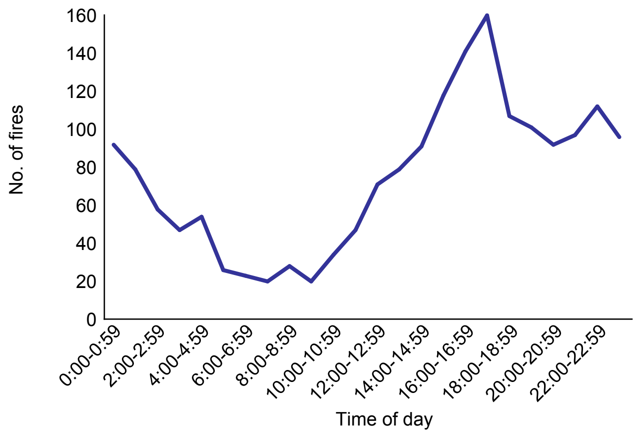
Source: SAMFS 1997–98 to 2005–06 [computer file]

Figure 20: Malicious vegetation fires at educational institutions and businesses by day of the week



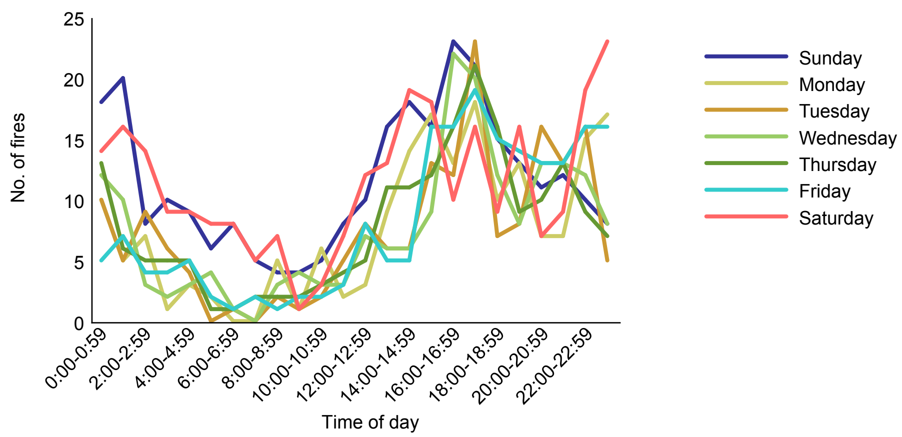
Source: SAMFS 1997–98 to 2005–06 [computer file]

Figure 21: Time of day for malicious vegetation fires



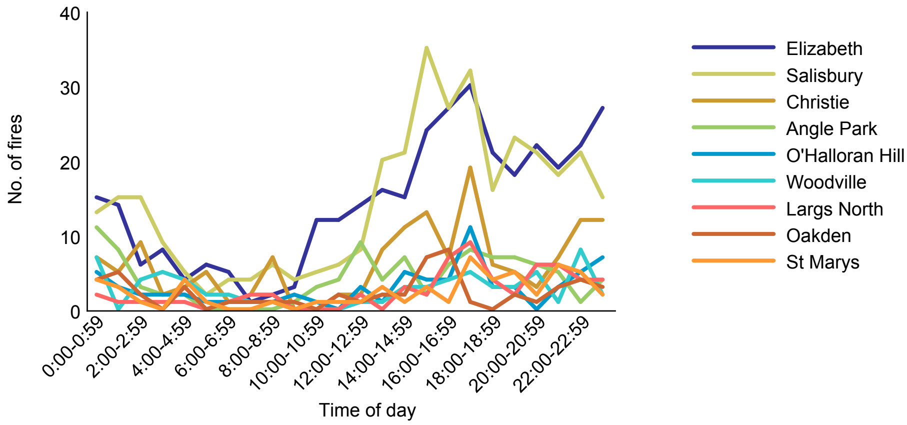
Source: SAMFS 1997–98 to 2005–06 [computer file]

Figure 22: Malicious fires in the Adelaide region by day of the week and time of the day



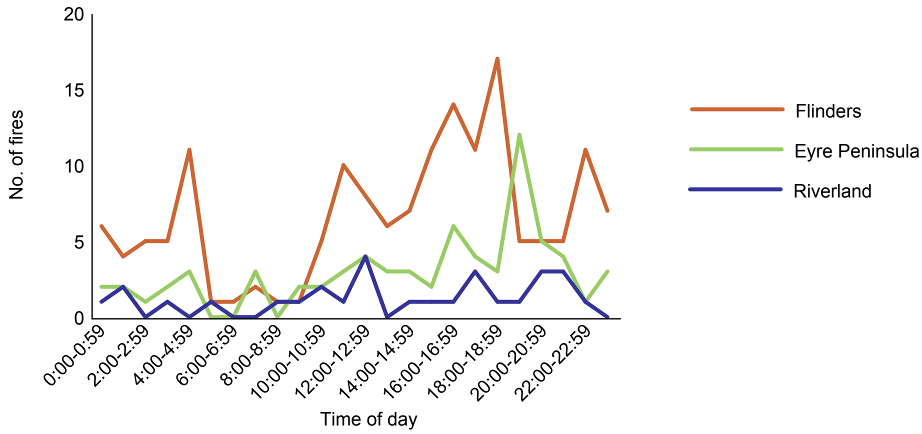
Source: SAMFS 1997–98 to 2005–06 [computer file]

Figure 23: Malicious fires at specific Adelaide stations by time of day



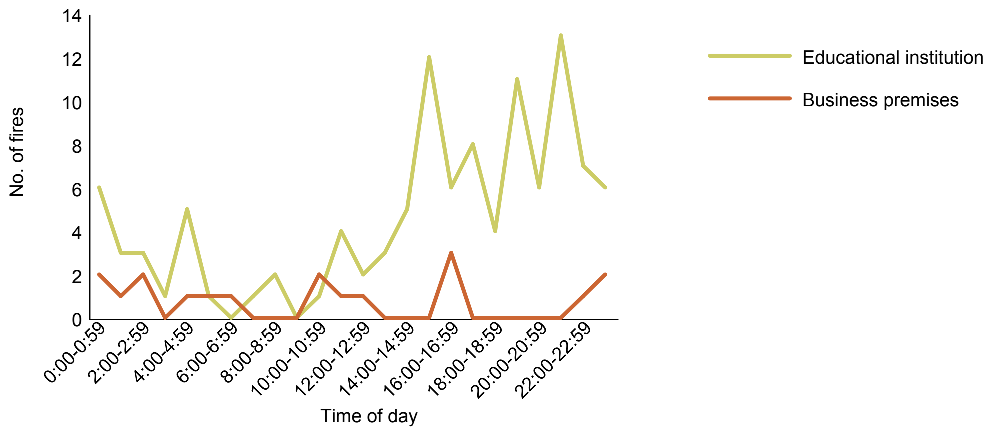
Source: SAMFS 1997–98 to 2005–06 [computer file]

Figure 24: Malicious fires in the Flinders, Eyre Peninsula and Riverland regions by time of the day



Source: SAMFS 1997–98 to 2005–06 [computer file]

Figure 25: Malicious vegetation fires at educational institutions and businesses by time of the day



Source: SAMFS 1997–98 to 2005–06 [computer file]

Area burned

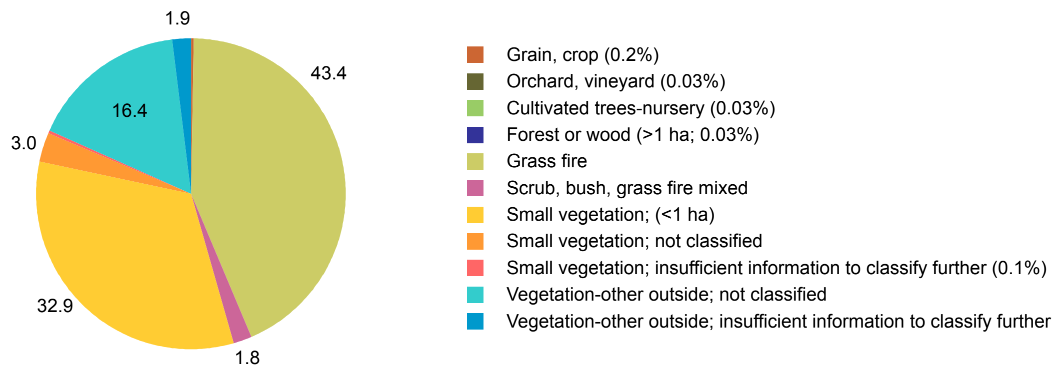
No information is available regarding the area burned.

Type of incident

Forty-three percent of malicious vegetation fires the SAMFS attended were classified as grassfires, with another 36 percent being small vegetation fires (Figure 26). The majority of the latter were identified as small vegetation fires less than 1 ha. Vegetation and other outside fires, either not classified or having insufficient information to classify, accounted for a further 18.3 percent of fires. There was only one incident where the SAMFS attended a malicious vegetation fire in forest or woods (greater than 1 ha; 0.03%) and 54 cases (1.8%) of malicious vegetation fires occurring in mixed scrub, bush or grass. Collectively, the proportion of malicious vegetation fires the SAMFS attended in areas used for agriculture, viticulture, orchard and/or nursery settings was less than one-quarter of one percent.

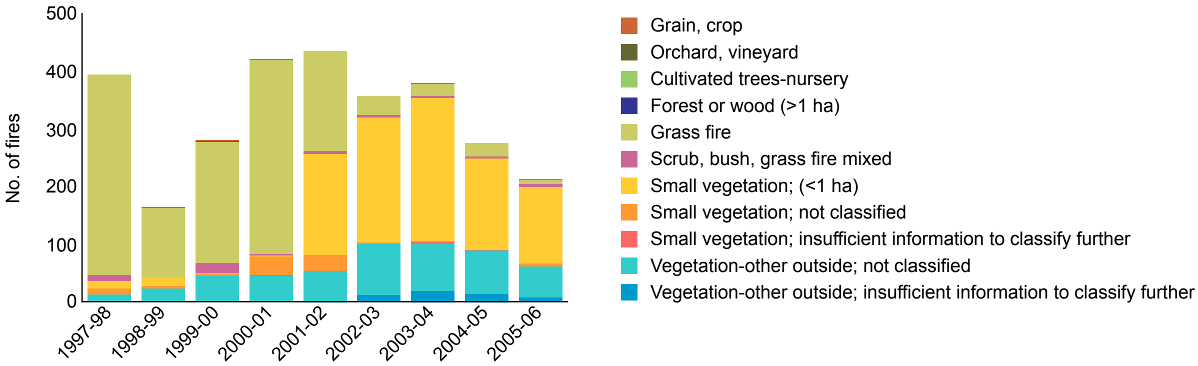
Some caution is required, however, in the interpretation of these results as there were substantive changes in the way fires were classified within the observation period. Worthy of note, is the substantive decrease in grass fires and the marked increase in the number of 'small vegetation fire', and 'vegetation and other outside fire' categories post-2001–02 (Figure 27). These results imply that many fires now classified as small vegetation fires or other outside fires had previously been classified as grass fires. The predominance of grass fires over forest, woods, or mixed scrub, bush and grass fires, are a feature of South Australian fires generally (see SACFS) but also reflects the predominant environments that occur within or near urban centres.

Figure 26: Incident type (percent)



Source: SAMFS 1997–98 to 2005–06 [computer file]

Figure 27: Incident type by year



Source: SAMFS 1997–98 to 2005–06 [computer file]

South Australian Country Fire Service

Background about the SACFS dataset and its analysis

Important information regarding the SACFS dataset and the methodology employed to analyse it follows.

- The data was sourced from the South Australian Country Fire Service (SACFS).
- The dataset provided only included vegetation fires, crop and grain fires, and rubbish fires; only vegetation fires were included within this analysis. Hence, in the following discussion it can be assumed that any reference to a fire is referring to a vegetation fire.
- The dataset included vegetation fires from 1997–98 to 2003–04.
- Substantial changes in classification of fire causes and other documentation occurred during the analysis, meaning that the methodology adopted for the SACFS analysis was unique.
- Fire cause was defined based on the ‘additional factor’ and ‘fire cause’ variables.
- The database included information about the type of incident.
- Fires were classified as incendiary in all instances where the additional factor was coded incendiary, deliberate or malicious.
- Fires were classified as suspicious in all instances where the additional factor was classified as ‘suspicious circumstances’; refer to the Methodology details regarding causal attributions.
- The term deliberate in this analysis refers to all fires identified as incendiary or suspicious.
- Natural fires comprised fires classified as have resulted from lightning (56.9%) and heat from natural sources (29.3%).
- Some information about the form of heat of ignition was supplied in the database.
- Smoking-related fires fell within two categories: cause=‘matches, smoking devices, candles, lanterns’ and cause=‘heat from smokers materials’; based on the causal classification scheme adopted, 16.8% fires were accidental; 30.5% were incendiary; 5.3% were suspicious; 46% were classed as other.
- In this analysis all fires attributed to children were classified in the other category; no information was available regarding either whether the fires were considered malicious or about the age of the child.

- Regions used in the SACFS analysis are based on tourism regions defined by the Australian Bureau of Statistics (ABS 2005b). Assignation to region was based on the location provided. There was not an exact concordance between the location and tourism regions. The ABS define tourism region based on smaller statistical areas. Hence, ABS tourism regions potentially crosscut suburbs and postcodes. In this study, assignation was based on the highest levels of concordance between suburbs and tourism regions. Hence, there is not an exact correspondence between tourism regions used in this analysis and ABS tourism regions.
- The dataset included information pertinent to the area burned, but did not include information about the status of fire restrictions/total fires bans, fire danger index or tenure.
- The SACFS attends many SADEH fires, and there is likely a high degree of overlap between data for these two services.

For further detail refer to the Methodology.

Overview

Fires attended by the SACFS can be summarized as follows:

- The SACFS attended 8,603 vegetation fires (excluding crop, grain and rubbish fires) during 1997–98 to 2003–04. The minimum number of fires attended in any one year was 756 in 1999–2000 (Figure 28). The maximum occurred in 2002–03 (n=1,494), although this is not substantially different from the previous year (n=1,478). The number of fires exceeded 1,300 for the last four years of the observation period. The lack of markedly higher numbers of fires in 2002–03 is somewhat surprising given the severity of that bushfire season but may reflect active attempts to reduce the incidence of arson and promote bushfire awareness during that bushfire danger season.
- The SACFS is principally a rural fire service, although many smaller urban centres that do not have an urban-based fire service fall under its jurisdiction. Hence, the SACFS may potentially attend a diverse range of vegetation fire incidents, ranging from large bushfires to small, urban incidents. The SACFS indicates that 53 percent of the fires attended were grass or stubble fires, 38 percent, scrub and grass fires, with a further 7.1 percent being tree fires. Only 1.7 percent of fires the SACFS attended were forest fires.
- Collectively, 20.2 percent of vegetation fires attended by the SACFS were deliberately lit (15.9% suspicious; 4.3% incendiary).
- 144,686 ha were burned in SACFS-attended fires from 1997–98 to 2003–04; 5.9 percent of this was burned in incendiary or suspicious fires.

Cause

The majority of fires the SACFS attended originated from non-deliberate causes with 27.3 percent being accidental, 7.6 percent natural, and 10.9 percent resulting from other non-deliberate causes (Figure 29). Just over four percent of all fires were classified as incendiary, with a further 16 percent classified as suspicious. Collectively deliberate causes (incendiary and suspicious combined) were responsible for 20.2 percent of all fires and 30.6 percent of all fires where the cause was attributed (that is, not unknown).

Changes in the structure of the database during 1999–2000 and 2000–01 make assessments of long-term changes in cause difficult (see Specific ignition factors below), so the following analysis is restricted to 2001–01 to 2003–04. Between 200 and 300 deliberate fires occurred every year from 2001–01 to 2003–04, with the maximum (n=299) occurring in 2001–02. The proportion of deliberate fires remained comparatively uniform throughout this period ranging from a low of 19 percent in 2000–01 to a high of 24 percent in 2001–02.

The greatest number of natural fires occurred in 2002–03 (Figure 28), with high proportions of natural lightings occurring in both 1997–98 and 2002–03. However, the number of natural fires in 1997–98 was not substantially different from that observed in other non-El Niño years.

Specific ignition factors

Ignition factor: Changes in the types of information recorded in the SACFS database prevents a detailed comparison of how the ignition factors have changed across the entire interval (Figure 30), and for the purposes of consistency only the 2000–01 to 2003–04 data are discussed herein.

The specific ignition factor was not ascertained or recorded for almost half of fires (Figure 30), with the proportion of unknown ignition factors increasing from 39 to 52 percent from 2000–01 to 2003–04 (Figure 31). Burning-off was the greatest identifiable cause of SACFS-attended fires, followed by other causes, fires relating to machinery and vehicles, natural and other causes (principally rekindled fires and other unspecified causes).

The proportions of each ignition factor remained comparatively stable over the period. The notable exception was the increased frequencies of natural fires that occurred during 2002–03 and to a lesser extent 2000–01. Some caution should be exercised when interpreting these results. The comparatively high degree of unknown causes may mask genuine temporal variations. Moreover, the 'known' group may not be representative of the total as some types of ignition are more readily identifiable or attributable than others.

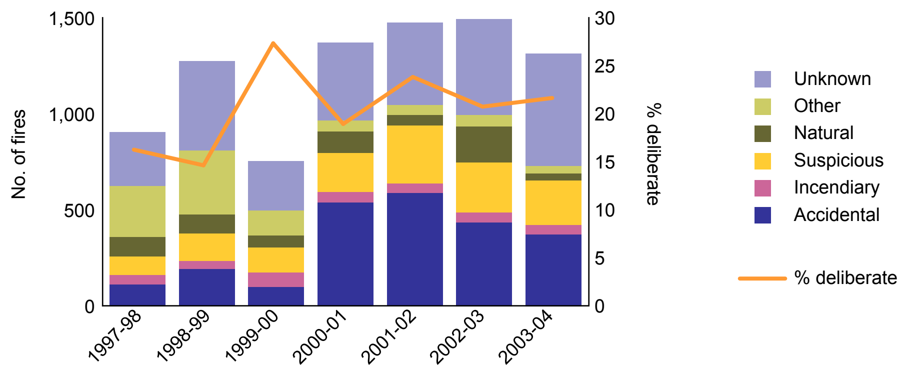
The ignition factor responsible for deliberate vegetation fires was unknown in 80 percent of cases (Figure 32). Burning-off accounted for a high proportion of deliberate lightings where the ignition factor was listed. Two-thirds of burn offs that were classified as malicious were lit without a permit.

Fires started by children: Children were identified as being responsible for 208 vegetation fires; that is, 2.4 percent of fires the SACFS attended between 2000–01 and 2003–04. There were between 39 and 59 fires in any given year, comprising between two percent and four percent of all fires each year (Figure 33). These statistics represent a minimum, as the causal category requires the child to be observed at the scene of the fire. Note: all fires started by children fall within the 'other' causal category. No judgement was available within the database as to whether the fires were maliciously lit.

Smoking-related fires: It is difficult to accurately assess the number of smoking-related vegetation fires as such fires have been amalgamated with fires resulting from matches, candles and lanterns since 2000–01. Before this, data were in separate categories.

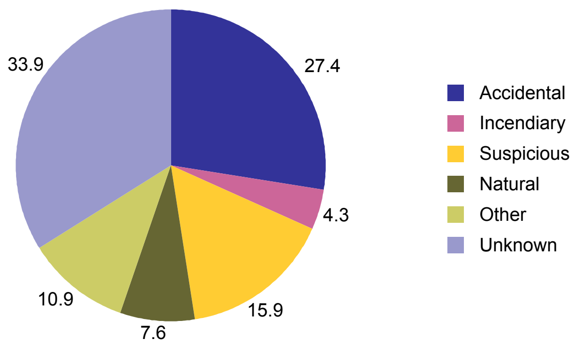
Before 2000–01 the SACFS attended up to 26 smoking-related fires per year. Since 2000–01 there have been 30 to 44 fires started by matches, smoking-related materials, candles and lanterns each year (Figure 34). Overall, smoking-related fires comprised between two and three percent of all vegetation fires the SACFS attended each year.

Figure 28: Cause of fires each year



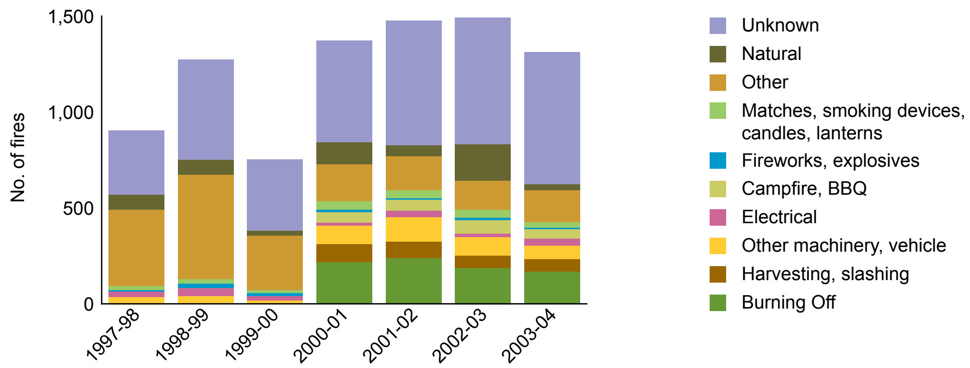
Source: SACFS 1997–98 to 2003–04 [computer file]

Figure 29: Fire cause (percent)



Source: SACFS 1997–98 to 2003–04 [computer file]

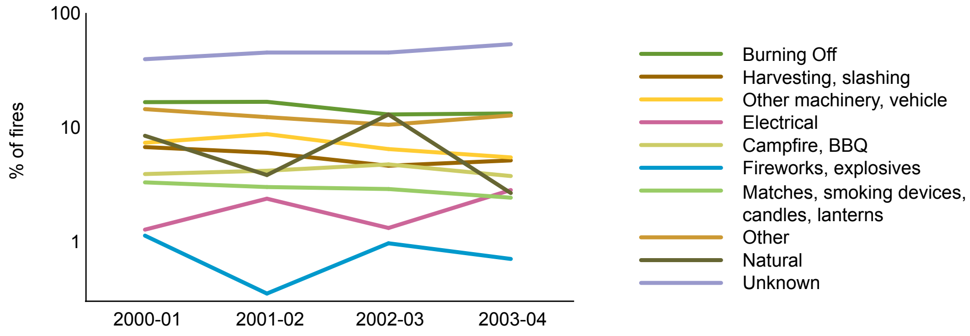
Figure 30: Ignition factor by year[a]



a: The abrupt change in the proportion of many factors at the end of 1999–2000 is consistent with a change in how causes of fires were encoded and documented

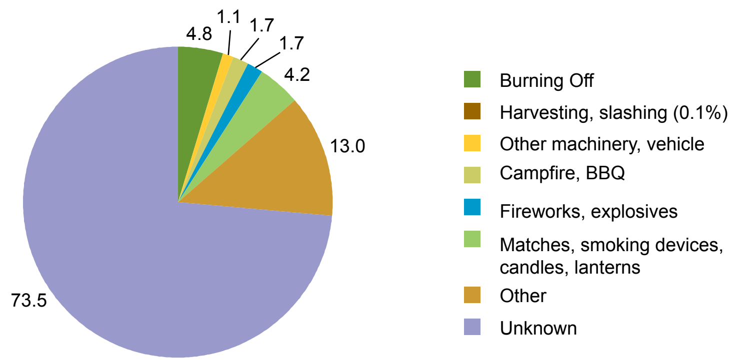
Source: SACFS 1997–98 to 2003–04 [computer file]

Figure 31: Ignition factor each year for 2000–01 to 2003–04 (percent)



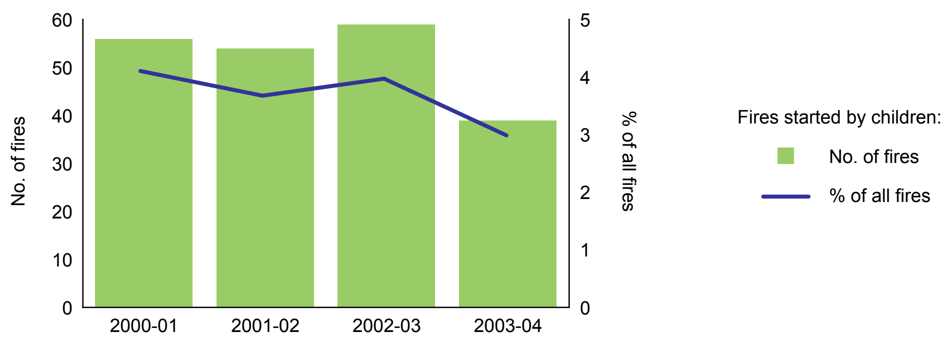
Source: SACFS 1997–98 to 2003–04 [computer file]

Figure 32: Ignition factor in deliberate fires



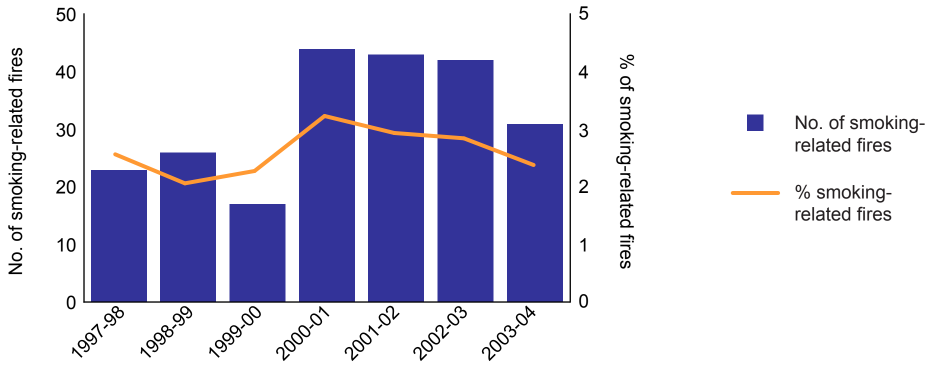
Source: SACFS 1997–98 to 2003–04 [computer file]

Figure 33: Fires lit by children, 2000–01 to 2003–04



Source: SACFS 1997–98 to 2003–04 [computer file]

Figure 34: Smoking-related fires (1997–98 to 1999–2000) and fires arising from 'matches, smoking devices, candles, lanterns (2000–01 to 2003–04)



Source: SACFS 1997–98 to 2003–04 [computer file]

Location

This section examines the regional distribution of vegetation fires generally and by cause.

Region

Thirty percent of all vegetation fires the SACFS attended occurred in the Adelaide (17%) and Adelaide Hills (13%) regions (Figure 35). A further 10 percent of fires occurred each on the Limestone Coast and Fleurieu Peninsula regions. Between four percent and seven percent of fires each occurred in the Yorke Peninsula, Eyre Peninsula, Murrylands, Flinders Ranges and Riverlands regions.

The greatest number of deliberately lit vegetation fires occurred in Adelaide, Fleurieu Peninsula, and Adelaide Hills regions (Figure 36). The proportion of deliberately lit fires was highly variable between regions, accounting for 41 percent of fires in the Adelaide region and 28 percent in the Fleurieu Peninsula and Riverland regions. In the Adelaide Hills, Limestone Coast and Yorke Peninsula regions, 20, 15 and 13 percent of fires were deliberately lit, respectively. Although a high proportion of fires in the Outback region were deliberately lit (40%), the number of fires was exceptionally low. Notably, only 0.7 percent of all SACFS-attended fires occurred in the Outback region.

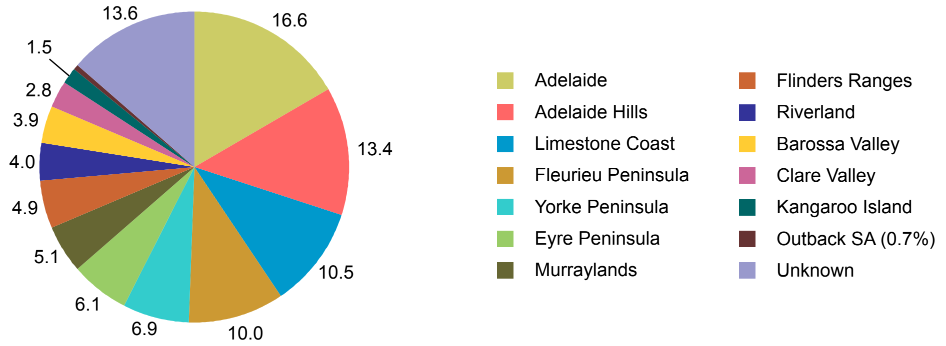
Other causal variations included:

Natural fires: The highest proportion of natural fires occurred in the Eyre Peninsula (18%), Limestone Coast (12%) and Flinders Ranges (12%) regions (Figure 36).

Child fires: Marked variations were evident in both the number and proportion of vegetation fires attributed to children in each region for the period 2000–01 to 2003–04 (Figure 37). The greatest number of child fires occurred in the Adelaide (n=66) and Fleurieu Peninsula (n=28). The highest proportions of fires attributed to children occurred in the Yorke Peninsula (5.4%), Barossa Valley (4.8%) and Adelaide (4.6%). A comparatively low proportion (1% to 1.5%) of fires in the Adelaide Hills and the Limestone Coast regions were attributed to children. Despite this variability there was, overall, a strong correlation between the numbers of fires set by children and total vegetation fire frequencies across regions ($r=.80$; $p<.001$).

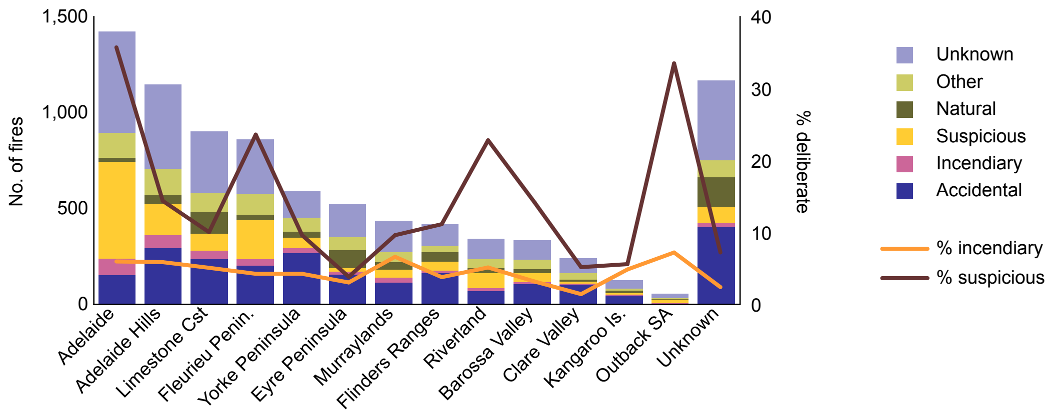
Smoking-related fires: The majority of fires started by matches and other smoking related materials, candles and lanterns occurred in the Adelaide (23%), Adelaide Hills (13%) and Fleurieu Peninsula (12%) regions (Figure 38). Fires attributed thus were responsible for the highest proportion of all fires in the Outback South Australia (5.3%), Murraylands (3.7 %), Adelaide (3.6%), Riverland (3.5%), and Fleurieu Peninsula (3.2%) regions.

Figure 35: Regional distribution (percent)



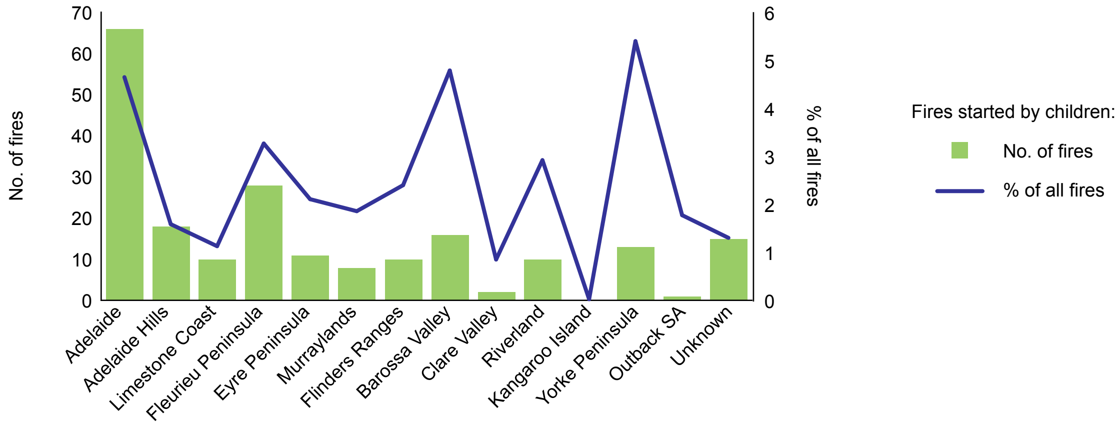
Source: SACFS 1997–98 to 2003–04 [computer file]

Figure 36: Cause of vegetation fires in each region (1997–98 to 2003–04)



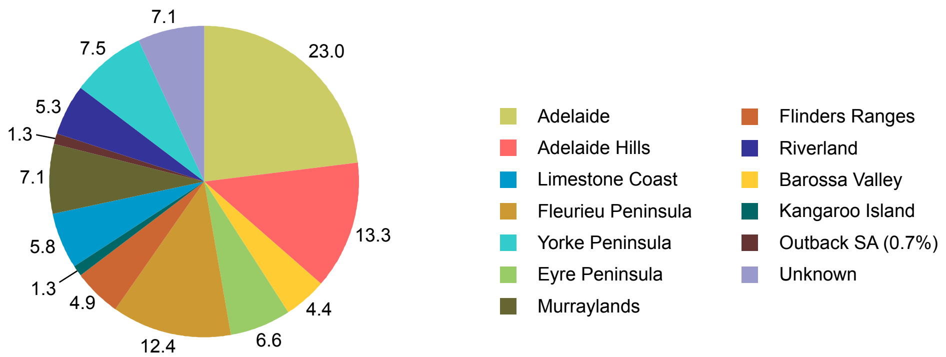
Source: SACFS 1997–98 to 2003–04 [computer file]

Figure 37: Child fires by region



Source: SACFS 1997–98 to 2003–04 [computer file]

Figure 38: Fires started by matches, smoking-related materials, candles and lanterns by region



Source: SACFS 1997–98 to 2003–04 [computer file]

Timing

The timing of fires is examined by week of the year, day of the week and time of the day.

Week of the year

The period of greatest bushfire danger in South Australia typically occurs from November–December through to late March–mid April. The vast majority of fires the SACFS attended occurred within this interval. Namely, the number of fires increased sharply in late October, typically peaking in January, and remained elevated until the end of the bushfire danger season, in March or April (Figure 39).

Although this general pattern occurred for both deliberate and non-deliberate causes, it is evident that deliberate fire 'season' tends to be marginally shorter than that for non-deliberate fires. Most deliberate fires occurred between weeks 44 and 17 as opposed to weeks 40 to 20 for non-deliberate fires. This difference principally reflects the high contribution that burn offs make within the non-deliberate fire category. Burn offs peak just before (commonly up to late November–early December) and just after (commonly after late March to early April onwards) the period of greatest bushfire danger (Figure 40).

Subtle differences were evident between the temporal distributions of other fire causes as well:

- Natural fires were typically restricted to the summer months (Figure 40). The rather spiky pattern for natural fires reflects evidence that a front of thunderstorm activity moving across the state generates multiple fires in the same week. Such weeks of intense weather activity tend to be erratically distributed within and between bushfire danger periods.
- Fires resulting from harvesting and slashing peaked in November and December, but remained elevated until late March.
- High numbers of escapes from campfires and barbeques occurred in September and April (Figure 40), being largely coincident with school holidays, when greater numbers of people are likely to be camping and less stringent or no fire restrictions are in force.
- Although fires started by children occurred throughout the year, the greatest number coincided with the peak in vegetation fires generally (Figure 41). The highest number occurring in December and in week 5, coinciding with the start of the school holiday and resumption of the school year. A high number of fires were also recorded in mid April, which may have coincided with the Easter school holidays. Child fires typically comprised less than four percent throughout the bushfire danger period but up to 10 to 18 percent in some weeks during winter.

The regularity with which the bushfire season commences each year (Figure 42), while shaped by the patterns of burning-off, ultimately reflects the consistent decrease in rainfall during the same period for all years for central (such as the Mount Lofty ranges) and northern South Australian latitudes (Figure 43). The decrease in rainfall is less systematic for the Lower Southeast, where there may be late spring or early summer rainfall (Figure 44).

While this is the general pattern, early spikes in fires were evident in week 44 (early November) and to a lesser extent week 37 (mid September) of 2002–03. Fires in week 37 primarily related to burn offs and suspicious causes, the large spike in week 44 principally arose from the 147 fires started by lightning in that week (Figure 42). Ignition of a large number of natural fires in 2002–03 was markedly earlier than in other years. However, in 2002–03, low rainfall, possibly arising from the El Niño weather patterns, was felt most strongly in the more northerly portions of the state. Average annual rainfall during spring and summer was comparable to that observed in other years.

The number of fires from January to April tended to vary substantially between years, reflecting the more erratic nature of rainfall in this interval from year to year. The rainfall distribution during late summer to autumn became more erratic northwards (Figure 43 and Figure 44), and would therefore have had a greater impact on northern than on southern regions. This erratic nature was more evident for non-deliberate causes compared to deliberate, supporting the contention that changes in bushfire danger may play a greater part in generating high numbers of fires than do specific changes in the actions of people.

It is not surprising that a large number of fires occurred in 2000–01 in light of the exceptionally low rainfall recorded in most parts of the state from November to February.

Day of the week

Overall, 33 percent more fires occurred on Saturday, but higher numbers of fires were not observed on Sunday compared to any other day of the week. Deliberate was the only cause of fire where the number of fires on both Saturday and Sunday exceeded those observed on weekdays (Figure 45). Incendiary fires were 50 to 60 percent more likely to occur on a weekend than during the week. In contrast, fires categorised as suspicious were 60 and 30 percent more likely to occur on Saturday and Sunday relative to the weekday average, respectively. A propensity for increased numbers of fires is also evident for ‘other’ fires, which includes fires started by children, fires relating to misuse of heat of ignition or material ignited and other unspecified causes. More accidental fires occurred on Tuesday and Saturday than on other days of the week.

Differences were also noted in the tendency for weekend fires between regions. In the Adelaide and Adelaide Hills regions, 24 percent and 16 percent more fires occurred on Sunday and 78 percent and 60 percent more occurred on Saturday than on the weekday average (Figure 46). In contrast, on the Fleurieu Peninsula 71 percent more deliberate fires occurred on Sunday and only 40 percent more fires occurred on Saturday relative to the weekday average, respectively. The Murraylands and Kangaroo Island regions documented much greater numbers of fires on Sunday relative to Saturday or the average weekday (300% to 500% of the weekday average) although absolute numbers of fires were lower, particularly for the Kangaroo Island region.

There is a strong tendency for children in regional and rural areas of South Australia to light more fires on weekends. Seventy and 40 percent more child fires occurred on Saturday and Sunday relative to the weekday average, respectively (Figure 47).

Time of the day

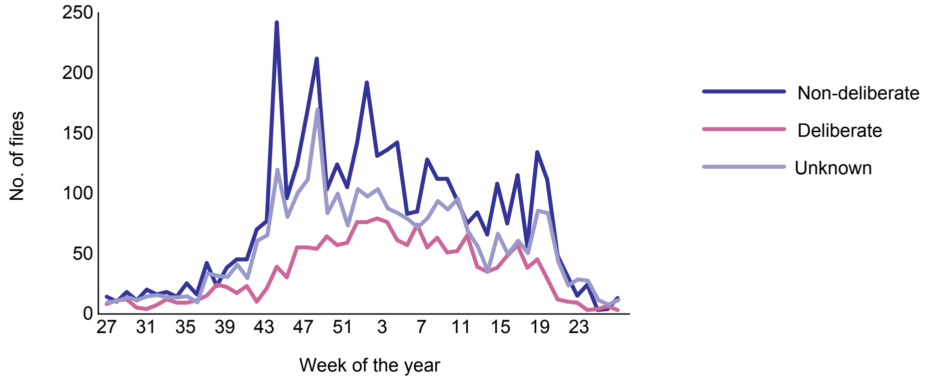
The vast majority of vegetation fires the SACFS attended were detected during daylight hours, but the distribution of fires throughout the day was highly dependent on cause. Non-deliberate vegetation fires mostly occurred between 10 am and 8 pm, irrespective of the day of the week, typically with peak frequencies occurring between 2 and 3 pm (Figure 48). The majority of deliberate fires also occurred between 10 am and 8 pm, although there was a tendency for maximum frequencies to occur slightly later, with the peak somewhere between 3 and 5 pm (Figure 49).

As observed elsewhere, greater numbers and proportion of deliberate fires occurred during the night, reaching a maximum during the early hours of the morning. Forty-three percent of all deliberate fires occurred between 6 pm and 6 am with 26 percent of deliberate fires occurring between midnight and 6 am. The spike in fires at night was most evident for Friday night–Saturday morning and for Saturday night–Sunday morning. Notably, 41 percent of fires between 6 pm and 6 am occurred on these two nights. Only five percent of non-deliberate fires were reported between these times.

Night fires were not a feature of all regions. Fifty-two percent of all deliberate fires in Adelaide occurred between 6 pm and 6 am, with 22 percent of deliberate fires in this region occurring between midnight and 6 am (Figure 50). Other regions to record a high proportion of deliberate fires between 6 pm and 6 am included the Flinders Ranges, Barossa Valley and Clare Valley regions (46% to 47% of fires occurred within this timeframe). However, with the exception of the Barossa Valley and Outback South Australia, where the total number of fires were low, the only other area outside of the Adelaide region to record a high proportion of fires between midnight and 6 am was the Fleurieu Peninsula (20%) and, to a lesser extent, the Adelaide Hills and Flinders Ranges regions (both 15%).

Regional differences in the propensity for deliberate vegetation fires at night may reflect differences in patterns of socialising. The dual peak pattern that is manifest in the Adelaide regions was also a feature of deliberate fires in the Perth region in Western Australia. Combined, the SAMFS and SACFS suggest deliberate night fires are a feature of more densely populated, principally urban areas, but such fires can potentially account for a high proportion of all fires that occur in some regional areas, even though the total number of fires was low. Fires on Friday and Saturday nights and the following mornings played an important role in generating greater numbers of fires on weekends relative to weekdays. This is, however, not a suitable explanation for an increased number of child fires on weekends relative to weekdays. Comparatively few fires started by children occurring between midnight and 9 am. Children lit most fires between 4 and 6 pm (Figure 51).

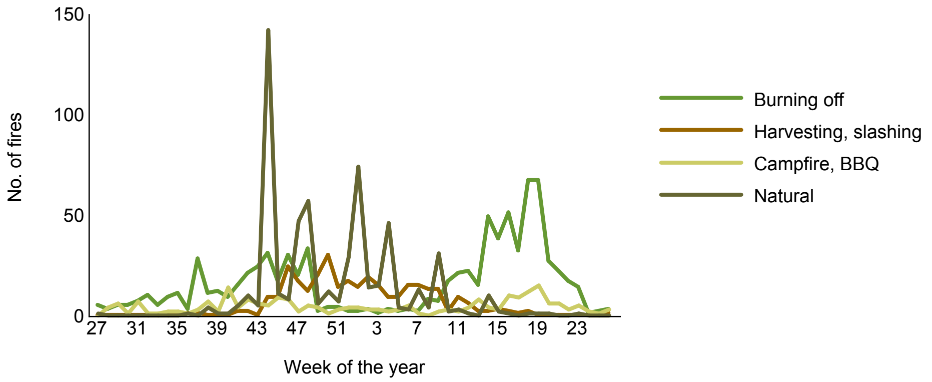
Figure 39: Week of the year[a] fires occurred by cause



a: Week 1 corresponds to the first week of January

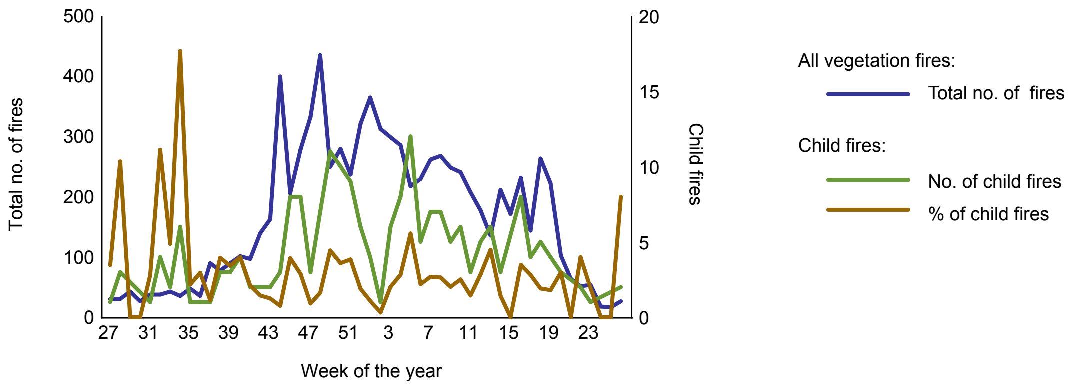
Source: SACFS 1997–98 to 2003–04 [computer file]

Figure 40: Week of the year that specific fire causes occurred



Source: SACFS 1997–98 to 2003–04 [computer file]

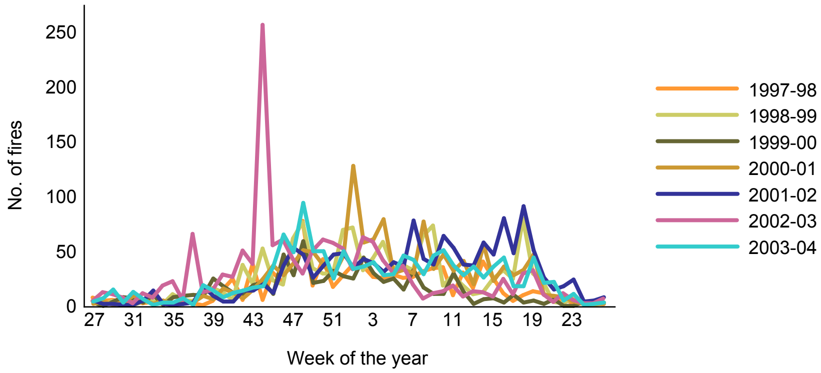
Figure 41: Child fires by week of the year



Note: Total refers to all fires of all causes and % Child is the percentage of all fires that occurred in that week that were attributed to children

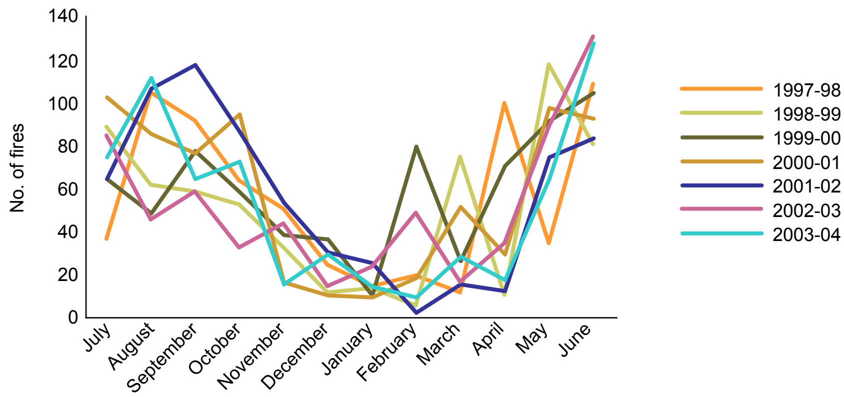
Source: SACFS 1997–98 to 2003–04 [computer file]

Figure 42: Week of the year by year for fires of all causes



Source: SACFS 1997–98 to 2003–04 [computer file]

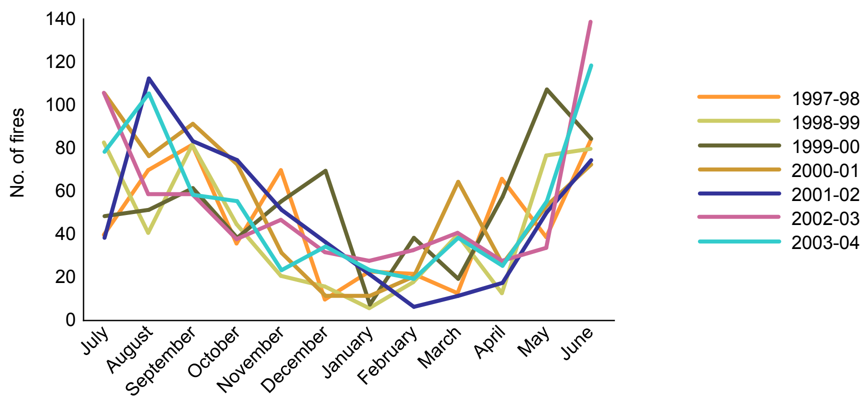
Figure 43: Mount Lofty Ranges – district rainfall average[a], 1997–98 to 2003–04



a: Data in this figure is based on monthly gridded rainfall data

Source: Australian Bureau of Meteorology [computer file]

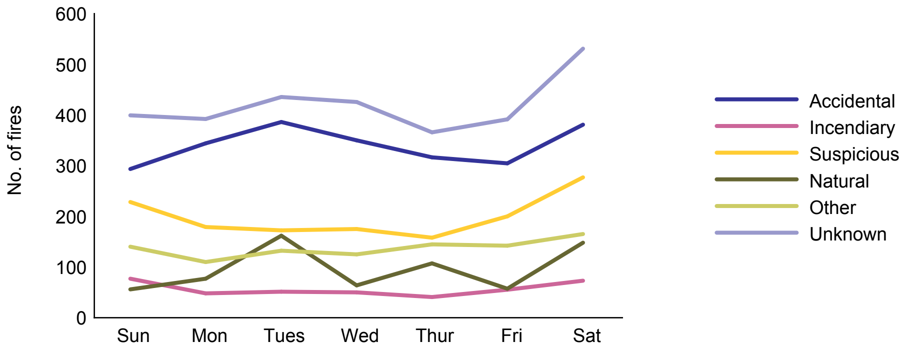
Figure 44: Lower Southeast South Australia –district rainfall average[a], 1997–98 to 2003–04



a: Data in this figure is based on monthly gridded rainfall data

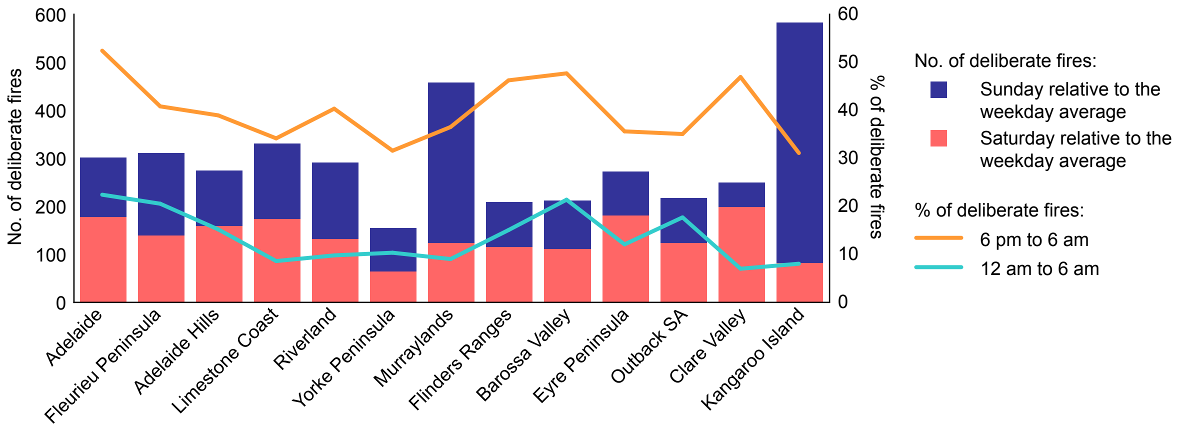
Source: Australian Bureau of Meteorology [computer file]

Figure 45: Day of the week by cause



Source: SACFS 1997–98 to 2003–04 [computer file]

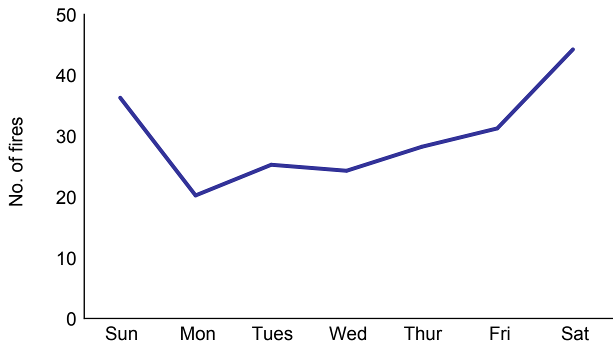
Figure 46: Deliberate fires on weekend and at night by region[a]



a: Sun and Sat rel to WDA, is the percentage of deliberate fires that occurred on Sunday and Saturday relative to the weekday average in each region. 6 pm to 6 am and 12 am to 6 am refer include data from all days of the week

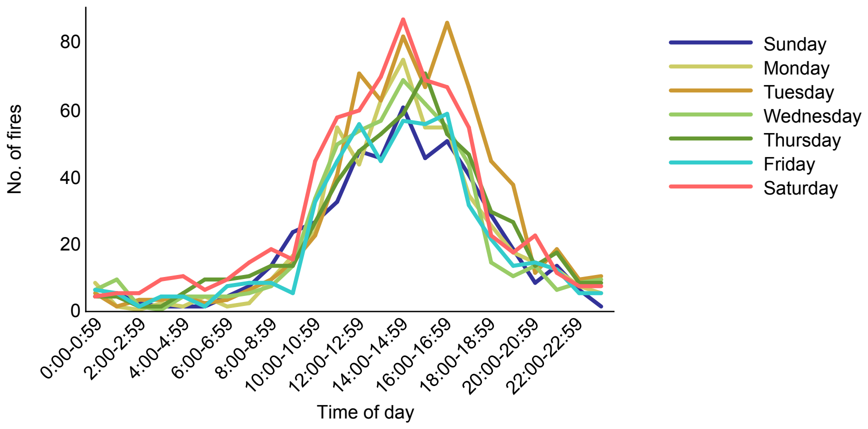
Source: SACFS 1997–98 to 2003–04 [computer file]

Figure 47: Child fires by day of the week



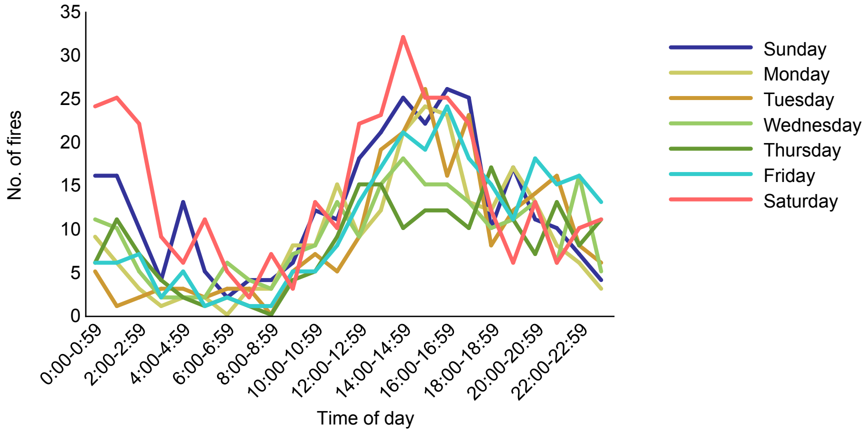
Source: SACFS 1997–98 to 2003–04 [computer file]

Figure 48: Non-deliberate fires by day of the week and time of day



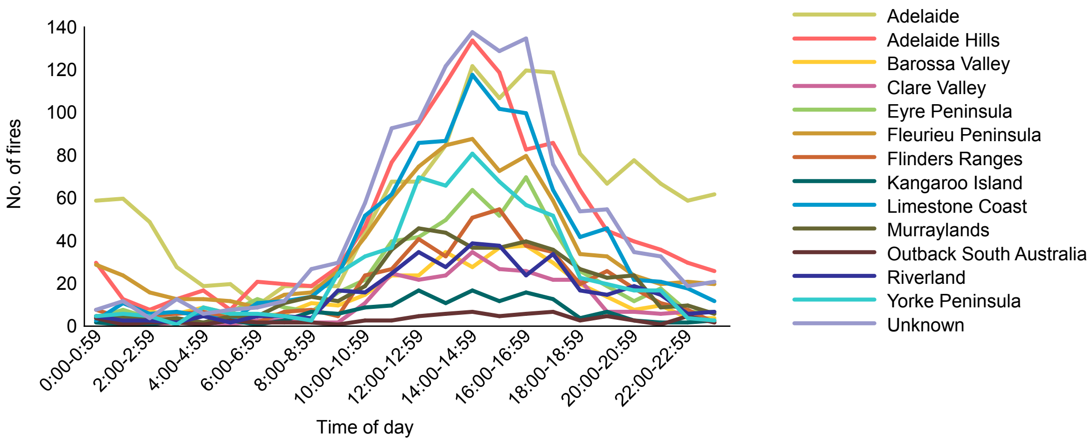
Source: SACFS 1997–98 to 2003–04 [computer file]

Figure 49: Time of the day at which deliberate vegetation fires were detected



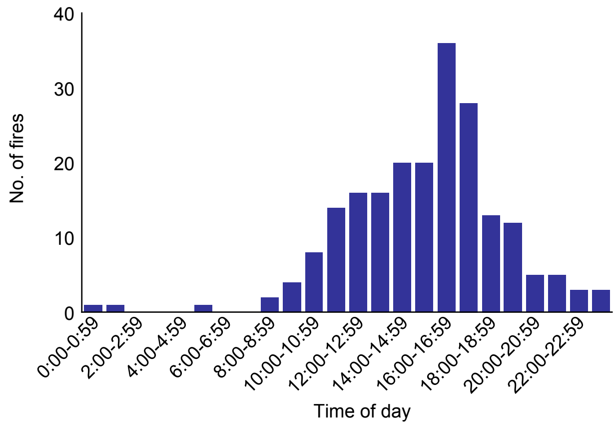
Source: SACFS 1997–98 to 2003–04 [computer file]

Figure 50: Time of day for all fires, by region, 1997–98 to 2003–04



Source: SACFS 1997–98 to 2003–04 [computer file]

Figure 51: Time of the day for child fires



Source: SACFS 1997–98 to 2003–04 [computer file]

Area burned

The number of fires decreased with increasing fire size, but with a characteristic ‘hump’ for fires in the 10 to 49.9 and the 100 to 499 ha ranges (Figure 52). This trend occurred for all fire cause categories, although there was a tendency for deliberate fires to comprise a small proportion and natural fires to comprise a greater proportion of each size category as fire size increased (Figure 53). The rigorousness of this relationship breaks down for larger area categories, owing to the lower number of large fires.

Nevertheless, two suspicious fires burned 1,000 ha or more during 2002–03 and 2003–04. These included a suspicious fire than burned 1,186 ha in the Adelaide region in 2003–04 and another that burned 1,000 ha in the Flinders Ranges region during 2002–03. The large incendiary fire recorded in the 2,000 to 4,999 ha category in Figure 53 resulted from the rekindling of a previous fire. It is unclear from the database if the previous fire was suspicious, or this represents one of the cases of classification inconsistencies (see Methodology chapter).

The occurrence of large fires largely governs the amount burned in any one year. As large fires are not a frequent occurrence, they were unevenly distributed both spatially and temporally. The largest area was burned in 2002–03, followed by 1997–98 and 1998–99 (Figure 54). Natural causes were the greatest known contributor to the total area burned during the 1997–98 and 2002–03 El Niño events. Five natural fires burning 1,000 ha or more occurred during 1997–98. The largest burned 8,900 ha and 3,220 ha in the Murraylands and Eyre Peninsula regions, respectively. Collectively, fires in these two regions accounted for 60 percent of the total area burned in South Australia that year.

In 2002–03, two fires started by lightning strikes burned 6,800 ha on Kangaroo Island and a further 2,000 ha in an unspecified location. However, the cause of the two largest fires in 2002–03, fires that burned 15,000 ha and 18,000 ha in the Eyre Peninsula and Limestone Coasts regions respectively, was unknown. These two fires were the largest recorded during the seven-year period. The 2002–03 fire season was remarkable for the SACFS in that large fires (exceeding 1,000 ha) occurred in at least four separate regions of the state. Owing to the location of the large fires, the greatest total area burned in 2002–03 occurred in the Limestone Coast, Eyre Peninsula and Kangaroo Island regions.

Accidental causes were singly the largest contributor to the total area burned during non-El Niño years, contributing to between 45 and 67 percent of the total area burned in all years with the exception of 1999–2000. In 1998–99, two accidental fires burned 2,000 ha and 9,000 ha on the Limestone Coast and Eyre Peninsula, respectively. These fires resulted from design–installation deficiencies and the failure–

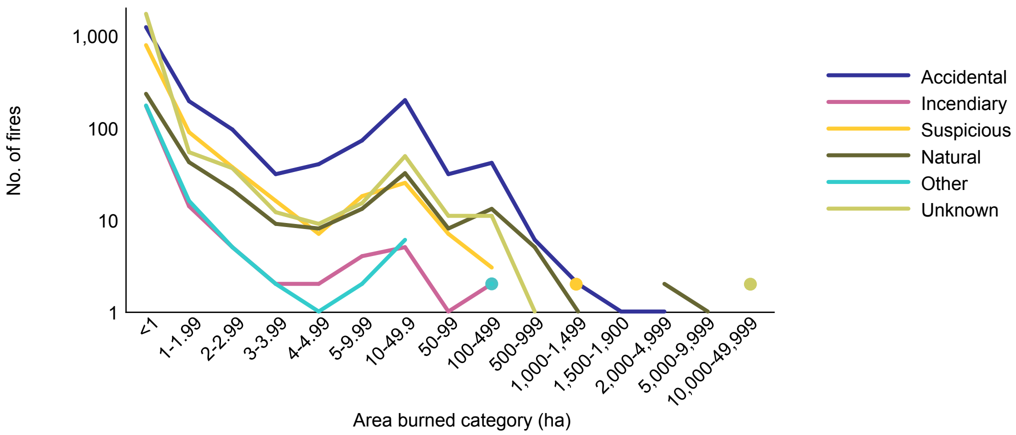
malfunction of fuel-powered machinery, respectively. In 2000–01, one accidental fire burned 1,200 ha on the Fleurieu Peninsula. No accidental fires in 2001–02 exceeded 1,000 ha, but 10 burned 100 ha or more. In 2003–04, three fires burned 1,100 ha (Yorke Peninsula), 1,500 ha (unknown location) and 4,285 ha (Limestone Coast). All resulted from electrical problems, the largest being related to power lines.

Collectively, deliberate causes were responsible for just 5.9 percent of the total area burned in SACFS fires (including the large of dubious origin, which accounted for one-fifth of the total areas burned by deliberately lit fires). Deliberate fires typically constituted a small proportion of the total area burned in SACFS-attended fires in any one year. In four of the seven years deliberate fires were responsible for four percent or less of the total area burned. Higher proportions were evident in 1999–2000 (21%), in a year when the total area burned was very low, in 2000–01 (16%) due to the inclusion of the 2,000 ha rekindled fire (discussed above), and in 2003–04 (10.5%).

Due to the density of larger fires, the greatest total area was burned on the Eyre Peninsula and on the Limestone Coast, with these regions accounting for 27 and 23 percent of the total area burned in South Australia, respectively (Figure 55). A comparatively high proportion also occurred in the Kangaroo Island (9%), Murraylands (8%) and the Yorke Peninsula (5%) regions. Just 2.9 percent and 0.9 percent were burned in the Adelaide and Adelaide Hills regions respectively. As noted, the total area burned in a region is dominated by large fire events. Many different factors can affect fire size, including location, accessibility, vegetation, weather conditions, fire-fighting resources, and the extent to which these fires are useful in terms of other fire management strategies.

The majority of fires lit by children are small. Approximately, 83 percent were less than one hectare. This compares to 76 percent for all fires (Figure 56). The largest fires lit by children burned 100 ha and 300 ha each. Both occurred in the Adelaide region. The total area burned by children for the four years incorporating 2000–01 to 2003–04 was at least 590 ha, being dominated by the two described events.

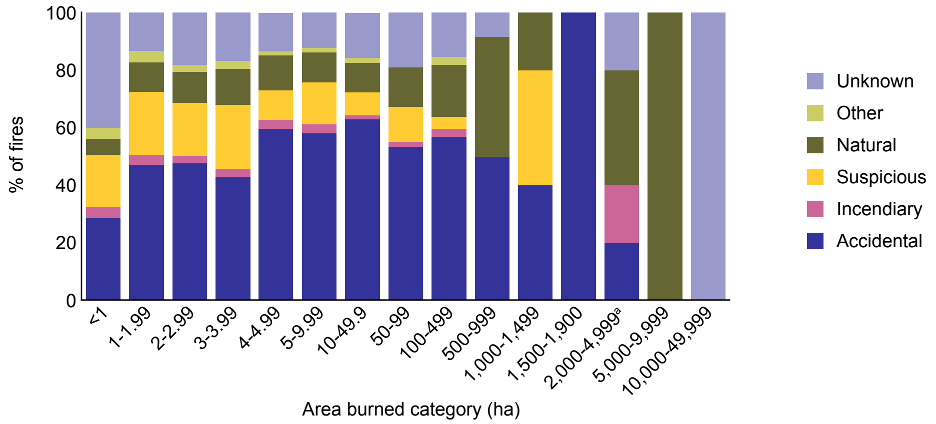
Figure 52: Area burned category by cause[a] (number)



a: Area data was available for 99.4 percent of fires

Source: SACFS 1997–98 to 2003–04 [computer file]

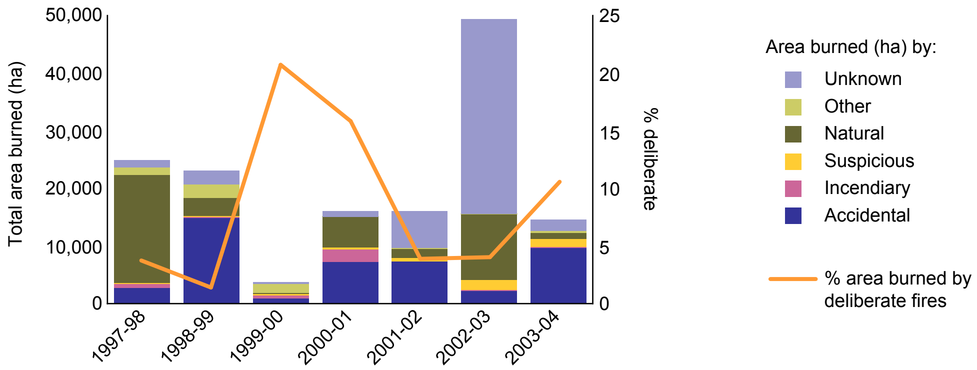
Figure 53: Area burned category by cause (percent)



a: The incendiary fire in the 2,000–4,999 ha category is listed as a malicious rekindle. See Methodology section for a discussion of issues pertaining to the classification of some data

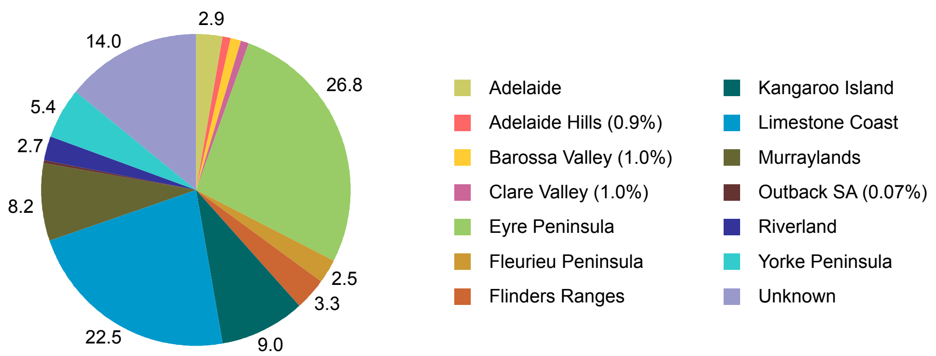
Source: SACFS 1997–98 to 2003–04 [computer file]

Figure 54: Area burned (ha) each year by cause



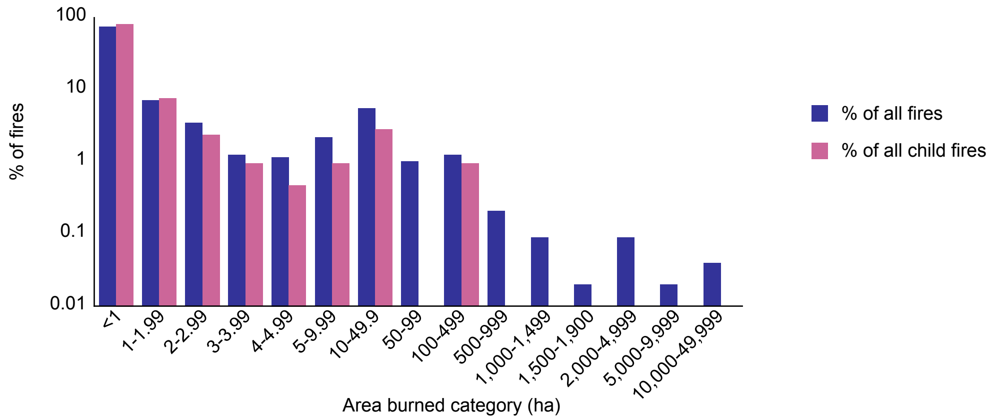
Source: SACFS 1997–98 to 2003–04 [computer file]

Figure 55: Area burned by region (percent)



Source: SACFS 1997–98 to 2003–04 [computer file]

Figure 56: Child fires by area burned category (percent)



Note: the size distribution of all vegetation fires is shown for comparison

Source: SACFS 1997–98 to 2003–04 [computer file]

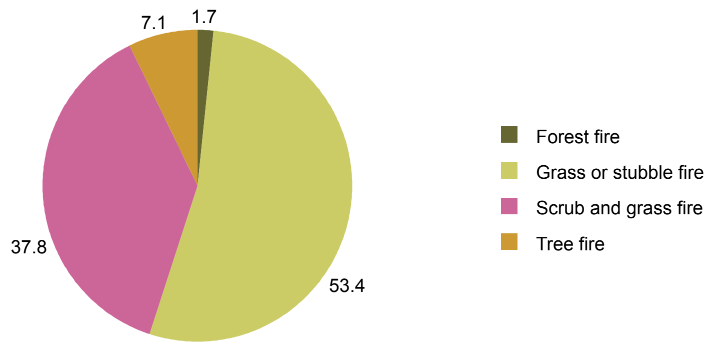
Type of incident

Fifty-three percent of all fires the SACFS attended were grass or stubble fires, with a further 38 percent being scrub and grass fires (Figure 57). Only seven percent were tree fires, with a further 1.7 percent being forest fires.

The proportion of deliberate fires was comparatively constant across all incident types, comprising 17 to 22 percent of each incident category (Figure 58). The proportion of accidental causes increased with increasing numbers of fires, being lowest for forest fires and highest for grass or stubble fires. The reverse was the case for natural fires, with fires resulting from natural causes comprising the greatest proportion of all forest fires, but a lower proportion of grass or stubble fires.

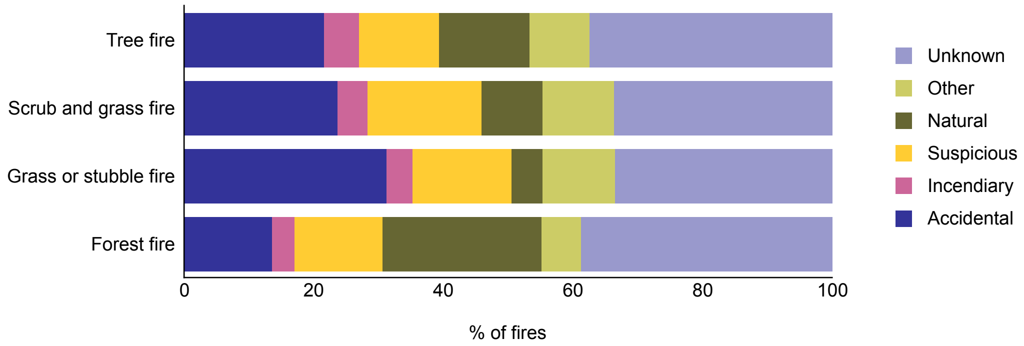
The dominant types of fires varied subtly across South Australian regions. For example, a lower proportion of grass or stubble fires occurred in the Adelaide Hills, Kangaroo Island, Riverland, Outback and Eyre Peninsular regions (Figure 59). These were areas characterised by a higher proportion of scrub and grass fires. Forest fires accounted for the highest proportion of fires in the Limestone Coast (7%) region, a finding that is not surprising given that most of the state's forests occur in that region.

Figure 57: Type of incident (percent)



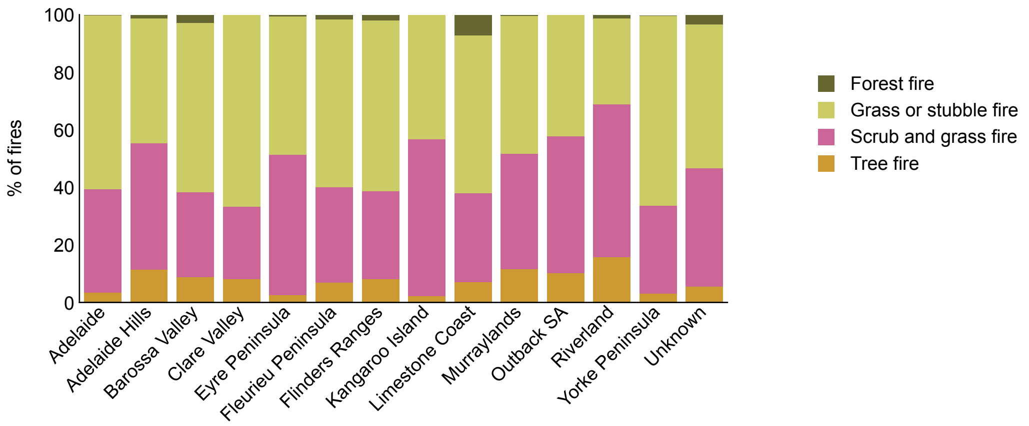
Source: SACFS 1997–98 to 2003–04 [computer file]

Figure 58: Incident type by cause (percent)



Source: SACFS 1997–98 to 2003–04 [computer file]

Figure 59: Type of incident in each region (percent)



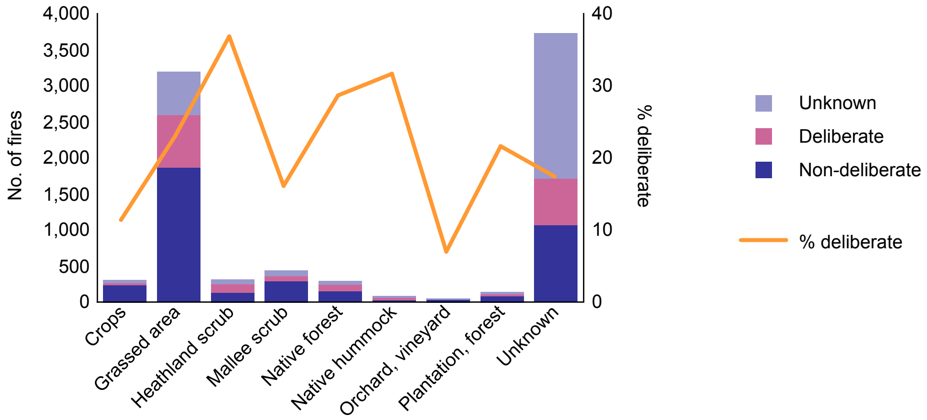
Source: SACFS 1997–98 to 2003–04 [computer file]

Vegetation

The type of burned was known in 57 percent of cases. Of these, the majority took place in grassland (including grazing) areas (Figure 60). Vastly smaller numbers of fires occurred in mallee scrub, heathland, crops and native forest.

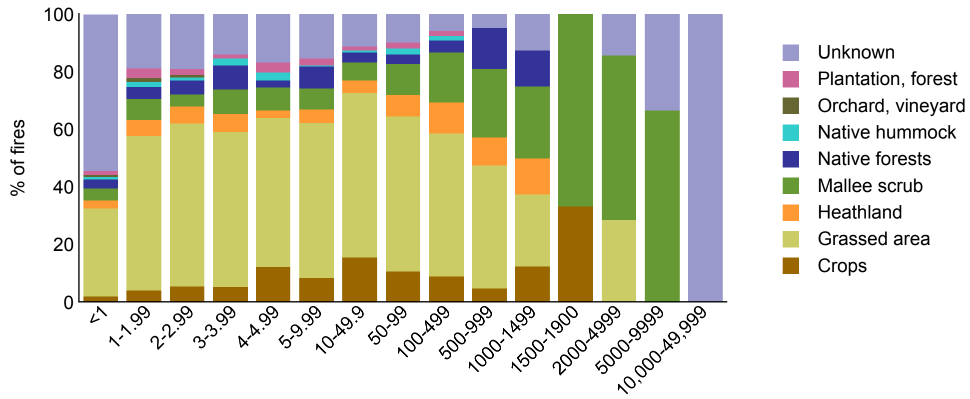
Deliberate causes constituted the highest percentage of fires that occurred in heathland (37%), native hummock grasslands (32%), and native forest (28%; Figure 60). Fires in mallee scrub accounted for an increasing proportion of fires as fire size increased. It appears that grassland fires accounted for a decreasing proportion of larger fires, in fire categories exceeding 100 ha (Figure 61). However, this is counter-balanced to a certain extent by the greater proportions of fires for which the vegetation type was listed as unknown. No fires in plantation or native forests exceeded 500 ha and 1,500 ha respectively.

Figure 60: Vegetation type by cause



Source: SACFS 1997–98 to 2003–04 [computer file]

Figure 61: Area burned category by vegetation type



Source: SACFS 1997–98 to 2003–04 [computer file]

South Australian Department of Environment and Heritage

Background about the SADEH dataset and its analysis

Important information regarding the SADEH dataset and the methodology employed to analyse it is summarised below.

- Data was sourced from the South Australian Department of Environment and Heritage.
- Dataset provided only included vegetation fires. Hence, all references to 'fire' in this analysis are vegetation fires.
- Fires occurred between1975–76 and 2003–04. This included fires from two separate datasets; 1975 to 2001 and 2001 to 2004. The variables used in these two datasets were not identical. Hence, the analysis is primarily restricted to variables in common.
- Cause was defined on the 'cause' and 'comment' (1975–2001) and 'fire cause' (2001–2004) variables.

- All fires where the cause was listed as arson have been classified as incendiary within the seven-fold classification scheme used in the analysis (accidental, incendiary, suspicious, natural etc.), as deliberate within the deliberate versus non-deliberate classification scheme and as arson, when the analysis specifically deals with the SADEH cause variable.
- The 1975 to 2001 subset in some cases included a descriptor in the comment section that indicated arson was suspected, although in the cause category it was indicated that the cause was unknown. The 2001–04 subset did not include this sub-category. For all fires within the 1975 to 2001 dataset, where the comment variable = 'Original cause description (July 2003): Suspected arson' have been classified as suspicious within the seven-fold causal classification scheme, and as deliberate within the deliberate versus non-deliberate classification scheme.
- Hence, in this analysis the term *deliberate* refers to all fires classified as either incendiary or suspicious.
- All fires classified as natural resulted from lightning.
- Information pertaining to smoking-related fires was only available for the 1975 to 2001 subset.
- No information was available about the role of children in lighting fires.
- District and region information used in the SADEH analysis are based on the fields provided by the SADEH.
- The dataset only includes the area burned in the 2001–04 subset.
- The dataset included information pertinent to the area burned, but did not include information about the status of fire restrictions/total fires bans, fire danger index or tenure.

Further detail regarding the analysis is outlined in the Methodology.

Overview

Important features of SADEH fires are summarized below.

- SADEH records indicate attendance at 1,534 fires from 1975–76 to 2003–04. This represents an average was 52.9 per year, but actual fire attendances ranged from a minimum of 18 in 1992–93 to a maximum of 86 in 1982–83 (Figure 62).
- Greater numbers of vegetation fires most commonly occurred in very low rainfall years (that is, 1982–83, 1984–85, 1994–95). Lower numbers of fires occurred in higher rainfall years (such as 1992–93). However, the long wavelength changes in the number of fires do not appear to reflect longer-term variability in summer rainfall patterns (Figure 63). Notably, fire frequencies were comparatively low during the 1990s, despite a number of those years (such as 1994–95) having very low rainfall. It is unclear to what extent these low values reflect inherent differences of bushfire danger versus changes to bushfire management strategies, greater targeting of bushfire arson or other factors. However, it is also evident from Figure 62 that the number of vegetation fires has subsequently begun to rise again in the 21st century.
- As the SADEH is a land management agency, it is reasonable to assume that a high proportion of all fires attended were either bushfires or had the potential, under adverse weather conditions, to develop into bushfires.
- Many of the fires included within the SADEH were also likely to have been attended by the SACFS.
- Arson was considered to have been the cause of 30 percent of all fires the SADEH attended.
- Over 7 million hectares was burned in SADEH fires from 2001–02 to 2003–04. This figure is dominated by several large fires in 2002–03, and hence does not provide an accurate guide to the total area burned by bushfires in South Australia each year, or the extent to which deliberate causes contribute to the total area burned each year.

Cause

Incendiary fires were responsible for at least 16.7 percent of fires SADEH attended in the period 1975–76 to 2003–04, with a further 7.3 percent being suspicious in origin (Figure 64). Hence, collectively, deliberate fires accounted for at least 24 percent of all SADEH-attended fires.

The number and proportion of deliberate fires varied substantially during that period, ranging from a low of two deliberate fires in 1992–93 to a high of 28 in 2002–03 (Figure 62). In any one year, deliberate fires were responsible for between seven and 38 percent of all fires. The greatest proportions of deliberately lit fires occurred in the last five or six years of the observation period. From 1999–2000 to 2003–04 deliberate fires accounted for 30 percent of all fires, ranging from 23 percent to 39 percent of fires in any one year (Figure 62).

However, caution is needed before assigning any meaning to this observation. Not only were there changes in the database structure, but also in the proportion of unknown causes. Unknown causes comprised 20 to 30 percent of fires up until the mid 1990s, but less than 10 to 15 percent of fires since then (Figure 65). Overall, deliberate causes comprised 31 percent of all fires where the cause was known, ranging from nine percent to 53 percent for any given year. There is no evidence for a longer-term change in the proportion of deliberate fires as a function of known causes (Figure 66).

Natural fires were responsible for 17 percent of fires from 1975–76 to 2003–04, early higher rates have been evident from the early 1990s (Figure 62). There are two distinct reasons for this increase. In the 1990s the number of natural fires was comparable to those observed previously, but owing to the low number of fires arising from other causes, natural cause accounted for a higher proportion of all fires. The higher proportion of natural fires since the turn of century reflects genuinely higher numbers of natural fires (Figure 62). In 2002–03 and 2001–02 natural fires were responsible for 42 to 43 percent of fires the SADEH attended. Natural fires comprised 30 percent of all SADEH-attended fires from 1999–2000 to 2003–04. However, again some caution is needed when interpreting these results owing not only to changes in the proportion of unknown causes, and changes in the database structure but also to potential changes in the way officers made causal attributions level of training available for officers.

Specific ignition factors

Other causes: Detailed information was available about the specific cause of fires within the ‘other causes’ category for the period 1975 to 2001, based on information available in the comment category. Comments were available for 92 percent of instances of fires from 1975 to 2001, where the cause variable was indicated as other (excludes fires where the comment variable was listed as rekindle, a possible rekindle or a suspicious fire which have already been re-allocated).

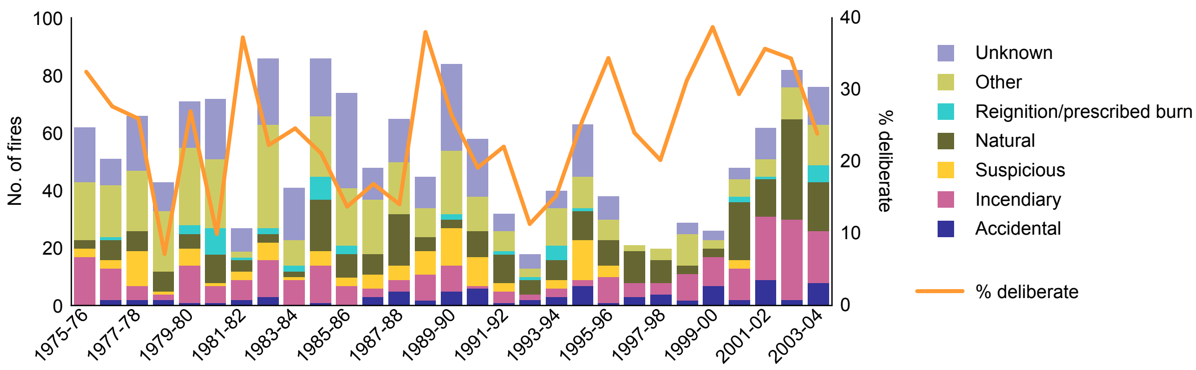
Of fires within the ‘other’ category, just over one-third was indicated as resulting from other causes, and no further information was available (Figure 67). In just over half (56%) of cases, the cause could have reasonably been listed as accidental. This includes fires started by agricultural machinery, power tools, power lines, escapes from neighbouring properties, barbeques, rubbish–incinerator fires, fires started by children, cigarettes or matches, exhausts, fires started by trains, and other specified causes.

Fire resulting from neighbours burning-off stubble and scrub constituted 16 percent of ‘other’ causes, children constituted 12 percent (includes cases of ‘possibly children’), and sparks from machinery and exhausts, including agricultural machinery, comprised a further 14 percent.

Although some caution is needed, given the low number of fires, there appears to have been an appreciable decrease in the number of fires started by children and/or resulting from neighbours burning over the observation period (Figure 68). This decrease, combined with the decrease in fires of unspecified ‘other’ causes, contributed to the overall decrease in the number and percentage of ‘other’ causes in

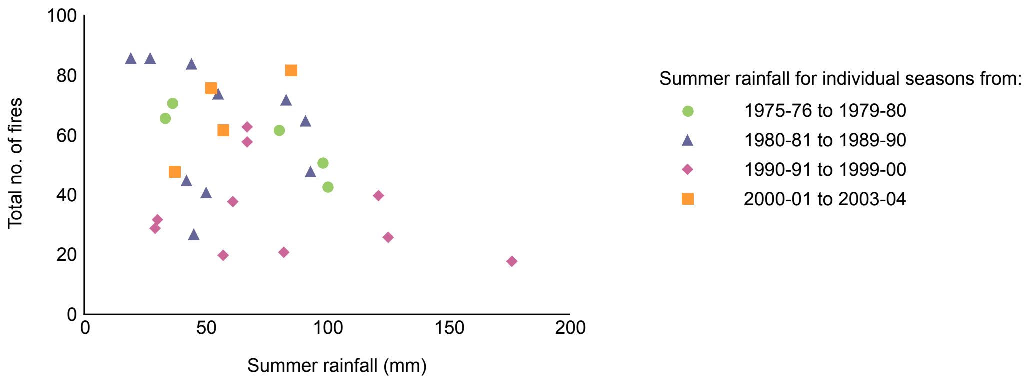
Figures 62 and 65. The number of smoking-related fires was small, and no apparent trend is evident in the temporal distribution of these fires.

Figure 62: Cause of fires by year



Source: AIC SADEH 1975–76 to 2003–04 [computer file]

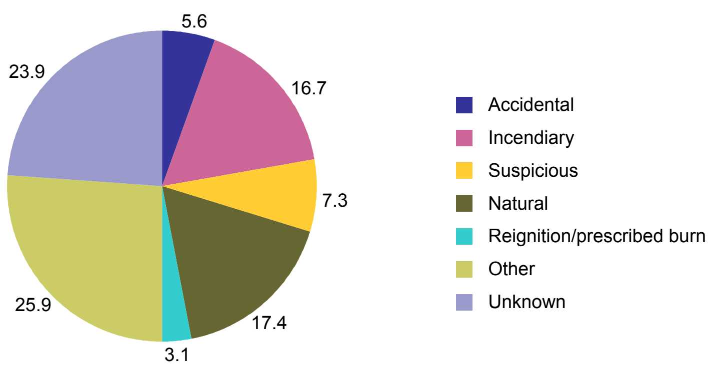
Figure 63: Yearly variation in the number of fires and summer rainfall[a], by decade



a: Data in this figure is based on the monthly gridded rainfall for the Mount Lofty Ranges district

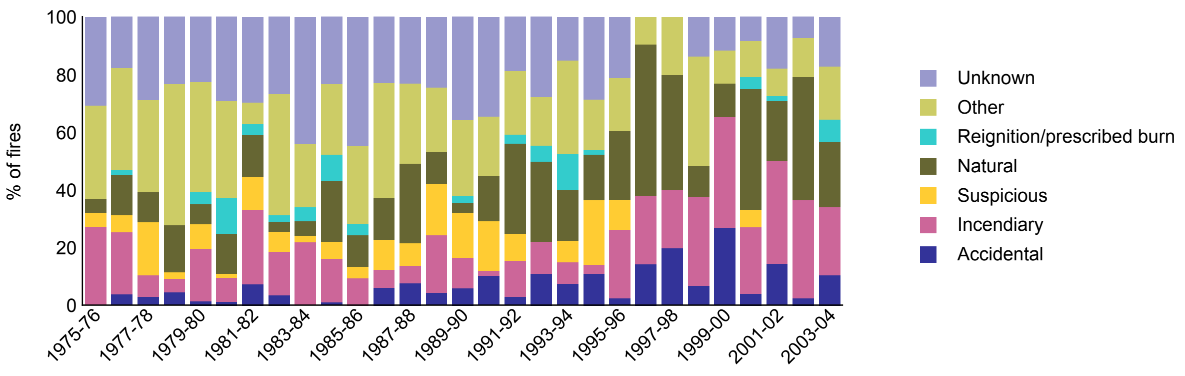
Source: Australian Bureau of Meteorology [computer file]

Figure 64: Fire cause (percent)



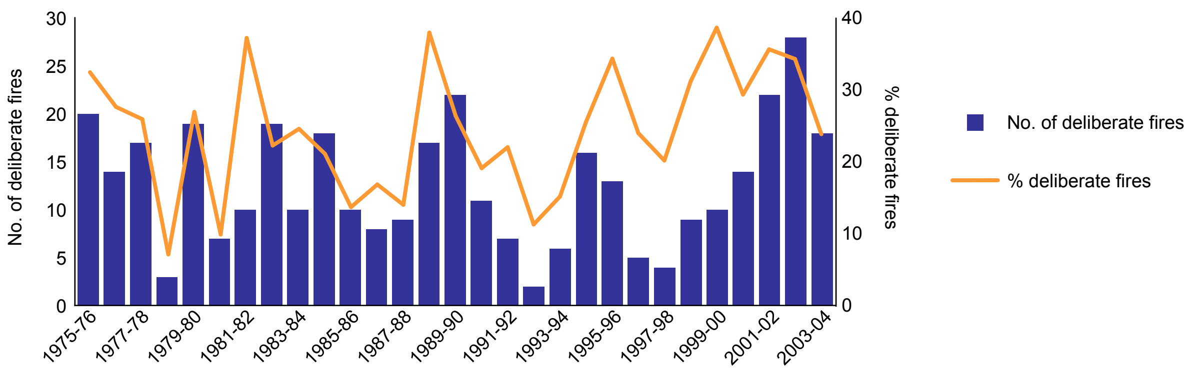
Source: AIC SADEH 1975–76 to 2003–04 [computer file]

Figure 65: Year by fire cause (percent)



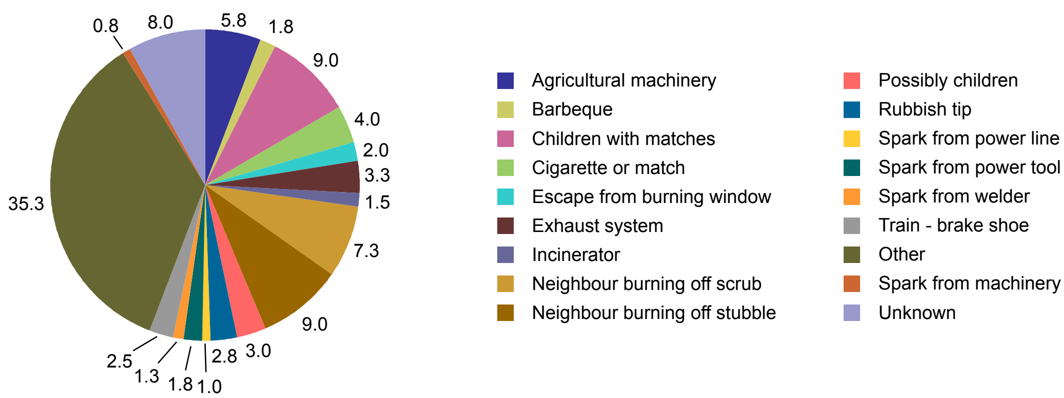
Source: AIC SADEH 1975–76 to 2003–04 [computer file]

Figure 66: Deliberate fires each year



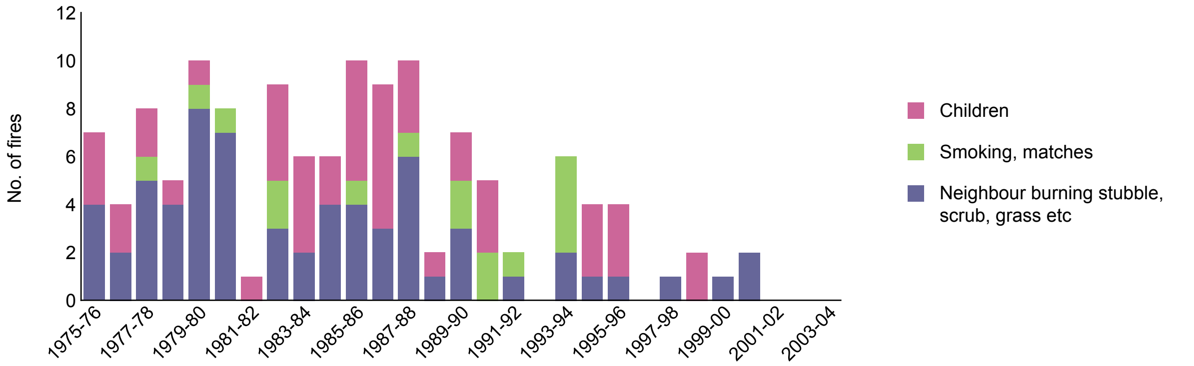
Source: AIC SADEH 1975–76 to 2003–04 [computer file]

Figure 67: Specific fire cause (percent)



Source: AIC SADEH 1975–76 to 2003–04 [computer file]

Figure 68: Fires resulting from neighbours burning, smoking or matches, and children, each year



Source: AIC SADEH 1975–76 to 2003–04 [computer file]

Location

The location of fires is described in terms of the region and reserve in which the fires occurred, and the point of origin and containment relative to SADEH land boundaries.

Region

The region structure adopted for this analysis is based on Australian Bureau of Statistics tourism regions (Figure 10), based on the name of the reserve. The correlation between reserve and tourism region was obtained from the SADEH, and is outlined in the Methodology chapter.

Almost one-third of all fires (33%) the SADEH attended occurred in the Adelaide region, with a further 20 percent being located in the Adelaide Hills (Figure 69). Other regional areas that accounted for comparatively high proportions of all SADEH-attended fires included the Limestone Coast (11%), Flinders Ranges (7%), and Eyre Peninsula (7%).

The principal causes of fires on SADEH-controlled land varied markedly between regions. The three regions characterised by the greatest number of fires – Adelaide, the Adelaide Hills and the Limestone Coast – also had a greater proportions of deliberate fires (23% to 36%; Figure 70). A high proportion (22% to 29%) of fires in the Clare Valley, Fleurieu Peninsula and Riverland districts were also deliberate, although the actual number of deliberate fires was low.

In contrast, the majority of fires, from 1975–76 to 2003–04, in Outback South Australia (71%), the Eyre Peninsula (59%), Riverland (46%), Flinders Ranges (43%), and Murraylands (75%) regions resulted from lightning strikes (Figure 70). Roughly one-third of all fires in SADEH-controlled reserves on Kangaroo Island were also the result of natural causes. Other causes were a significant factor in fires in the Yorke Peninsula (56%), Clare Valley (40%), Limestone Coast (38%), and Kangaroo Island (37%) regions.

Some subtle differences were evident in the principal causes of fires in individual regions during the period 1999–2000 to 2003–04 (Figure 71), when compared with the longer period of 1975–76 to 2003–04 (Figure 70); this reflects the temporal changes in fire causes outlined above. Proportionally, more fires occurred in the Eyre Peninsular region than in the Adelaide Hills, Limestone Coast and Flinders Ranges regions and fewer fires in the Murraylands region were deliberately lit. Deliberate causes remain the principal cause of fires in the Adelaide, Adelaide Hills (approximately 60% deliberate) and to a lesser extent the Fleurieu Peninsula (22% deliberate) regions.

Fires attributed to children principally occurred in the Adelaide and Adelaide Hills regions, and comprising seven percent and three percent of all fires attended by the SADEH in those regions from 1975–76 to 2000–01, respectively. Fires attributed to children were also responsible for 4.4 percent of fires in the Fleurieu Peninsular region and 2.7 percent of fires on Flinders Island.

Fires resulting from neighbours burning-off contributed to the greatest number of fires in the Adelaide Hills, Kangaroo Island, Adelaide and Limestone Coast regions. However, the total number of fires resulting from this cause did not exceed 18 in any one region.

Almost one-third of all fires that resulted from campfires between 1975–76 and 2002–03 occurred in the Adelaide region, which probably reflects the greater visitation rates afforded to parks by their accessibility. A further 13 percent of campfires occurred in the Limestone region, 11 percent in the Yorke Peninsula, nine percent in the Riverland and eight percent on the Eyre Peninsular (Figure 72).

Reserves

Three reserves – Belair, Onkaparinga River and Cleland – experienced between 100 and 130 fires (Figure 73) between 1975–76 and 2002–03. From 30 to 65 fires occurred on a further 11 reserves and 18 reserves experienced 10 to 29 fires. The six reserves that recorded the greatest number of fires in total all occurred either in the Adelaide or Adelaide Hills regions.

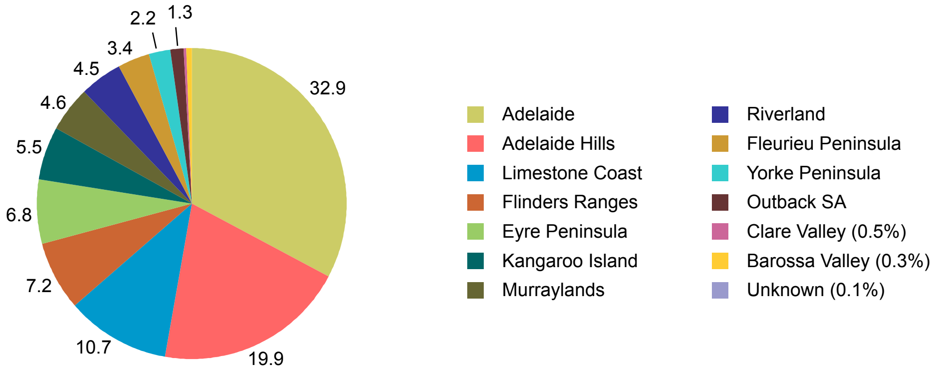
Higher numbers of deliberate fires were observed in all reserves that recorded in excess of 40 fires in total in the 29-year period, with the exception of Mount Remarkable (Figure 73). Higher numbers of deliberate fires were also recorded in the Cobbler Creek, Scott Creek, Murray River, Shepherds Hill and Sturt Gorge. Belair, Onkaparinga River and Anstey Hills recorded between 31 and 42 deliberate fires in 29 years. Black Hill, Cleland and Canunda recorded from 20 to 25 deliberate fires, and Morialta, Cobbler Creek, Scott Creek, Parra Wirra, Shepherds Hill and Murray River between 10 and 20 deliberate fires, in 29 years. With the exception of the Murray River and Canunda Reserves, all of the reserves with high numbers of deliberate fires occurred in the Adelaide and Adelaide Hills region.

The percentage of fires that arise from deliberate causes was highly variable across individual reserves, even among reserves that recorded higher numbers of deliberate fires (Figure 73). In parks documented above as having higher numbers of deliberate fires, typically between 20 and 70 percent of fires were deliberate. However, it is noted that in parks like Belair, Onkaparinga and Cleland the cause of a high proportion of fires was unknown and actual rates are likely to be much higher.

The largest number of natural fires occurred in the Ngargkat, Danggali Flinders Chase, and Mount Remarkable reserves, but this cause was also an important factor in the Billiatt, Coffin Bay and Hincks reserves.

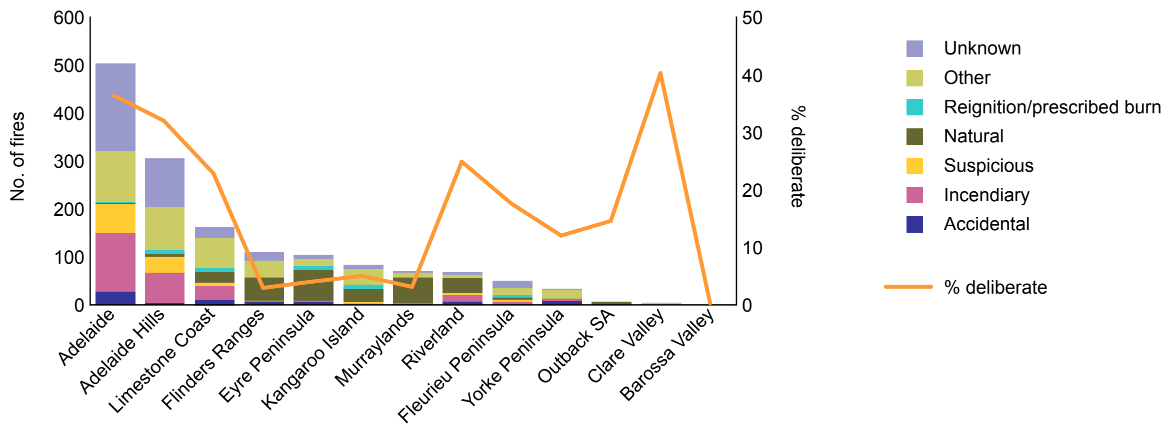
That generalised temporal trends are not necessarily an accurate guide to trends on a local scale is evident in the comparison of data from the Belair (Figure 74) and Onkaparinga River (Figure 75) reserves. Both reserves experienced a high number of fires generally and deliberate fires specifically. For the Onkaparinga River reserve activity, this principally occurred during the last six years of the observation period, reaching a maximum during 2001–02; it slowly began to increase in the late 1980s. In contrast, the majority of fires in the Belair reserve occurred in the 1970s and 1980s, with comparatively few fires occurring in the 1990s and 2000s. There was a clear spike in deliberate fires within this park in the mid to late 1970s. Deliberate fires have remained the principal cause of fires within the park, but absolute numbers of fires are very much lower. The decrease in the number of fires in accessible parks like Belair during the 1990s very much contributed to the decrease in the total number of fires the SADEH attended during the 1990s. Apart from Onkaparinga River, other reserves to record higher numbers of deliberate fires since 2000 include Cobbler Creek, Anstey Hill, Cleland and to a lesser extent Moana Sands.

Figure 69: Region fires occurred



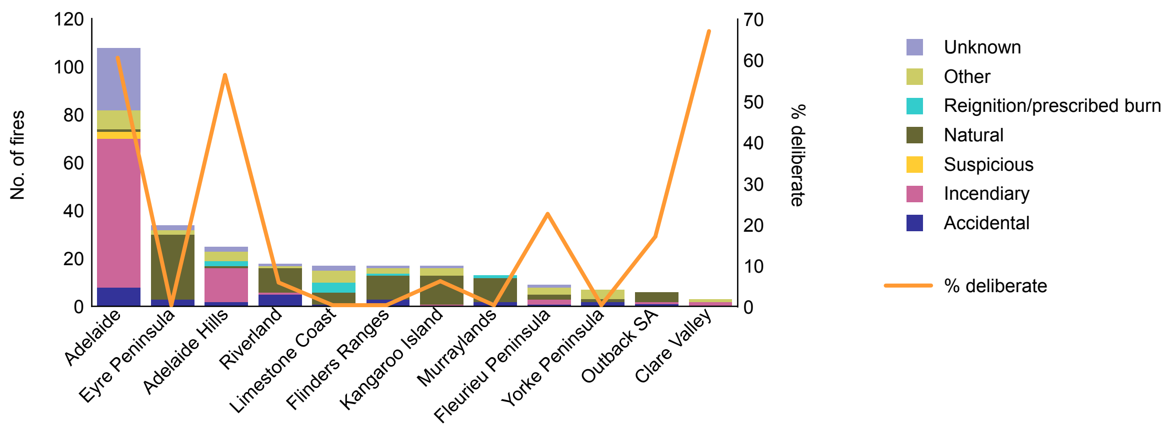
Source: AIC SADEH 1975–76 to 2003–04 [computer file]

Figure 70: Fire cause by region, 1975–76 to 2003–04



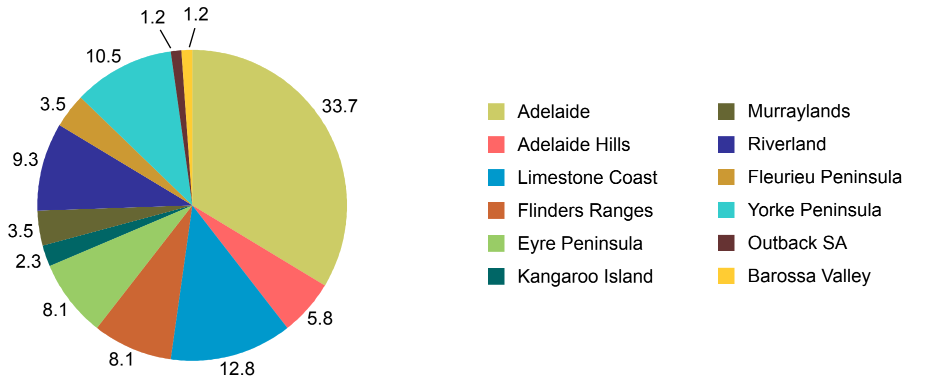
Source: AIC SADEH 1975–76 to 2003–04 [computer file]

Figure 71: Fire cause by region, 1999–2000 to 2003–04



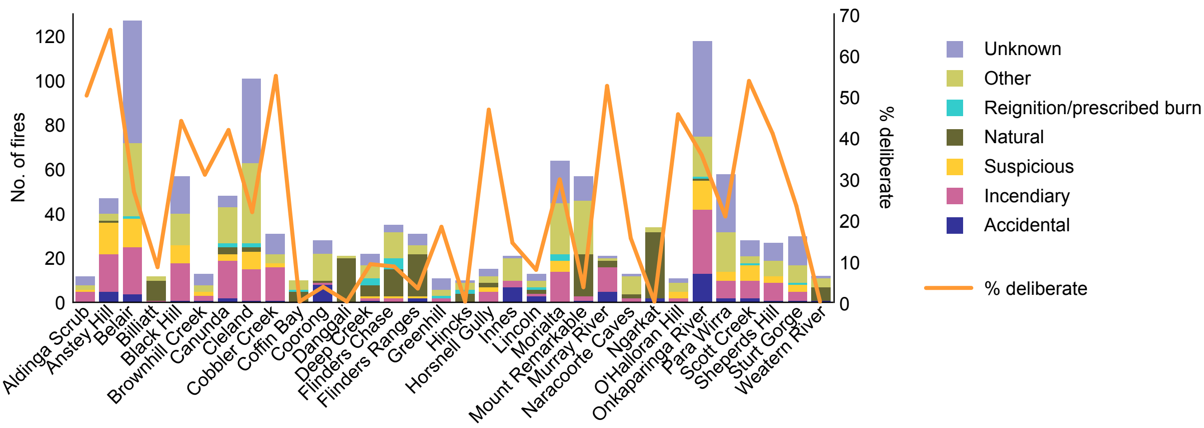
Source: AIC SADEH 1975–76 to 2003–04 [computer file]

Figure 72: Campfires by region (percent)



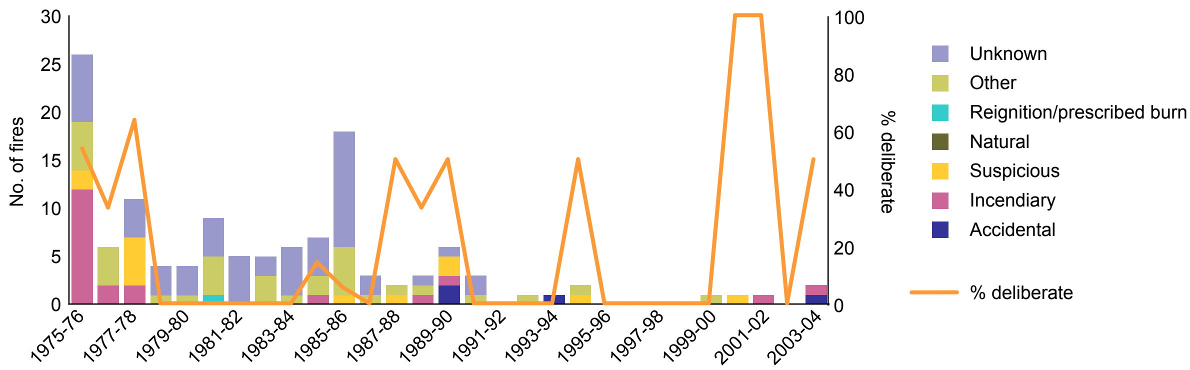
Source: AIC SADEH 1975–76 to 2003–04 [computer file]

Figure 73: Reserve by fire cause



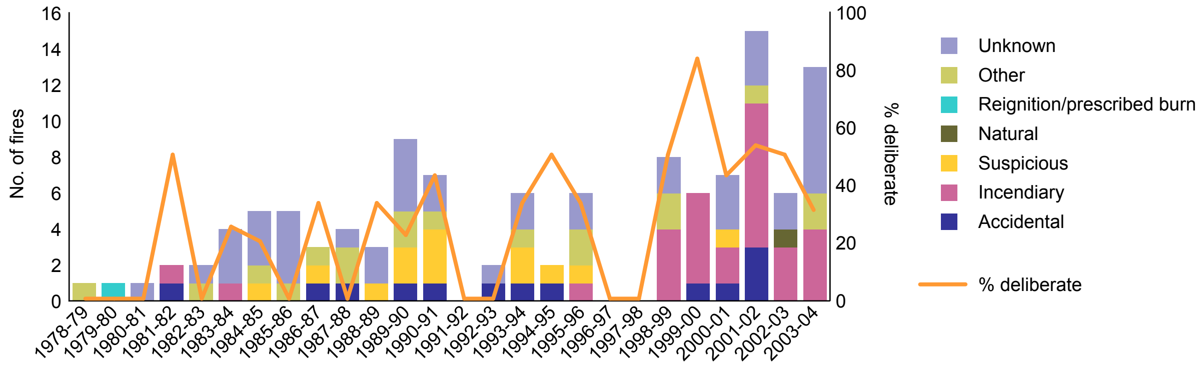
Source: AIC SADEH 1975–76 to 2003–04 [computer file]

Figure 74: Belair Reserve – fire causes each year



Source: AIC SADEH 1975–76 to 2003–04 [computer file]

Figure 75: Onkaparinga River Reserve – fire causes each year



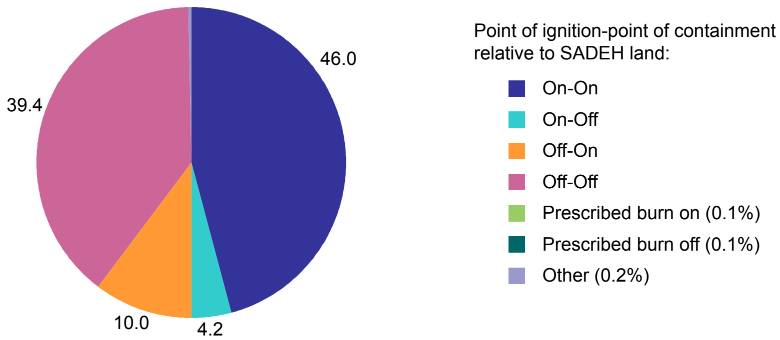
Source: AIC SADEH 1975–76 to 2003–04 [computer file]

On-Off status

Forty-six percent of fires the SADEH attended started on SADEH-controlled reserves and were contained on those reserved (Figure 76). Only 4.2 percent of fires started on SADEH reserves but escaped into other lands. Ten percent of fires started outside SADEH lands but crossed onto those reserves. A further 39 percent started off, and where contained off, SADEH reserves.

Deliberate fires principally were lit on reserves and contained on those reserves, or, to a lesser extent lit off reserves and contained off the reserve (Figure 77). A higher proportion of all fires that were lit on reserves were deliberate, when compared with those lit off reserves. Nevertheless, approximately one-quarter of all fires that were lit off a reserve but subsequently travelled onto reserves were deliberately lit. A further 40 percent of fires passing onto SADEH reserves resulted from other causes. In contrast, 45 percent of fires that started on a SADEH reserve and subsequently passed onto neighbouring lands were natural in origin.

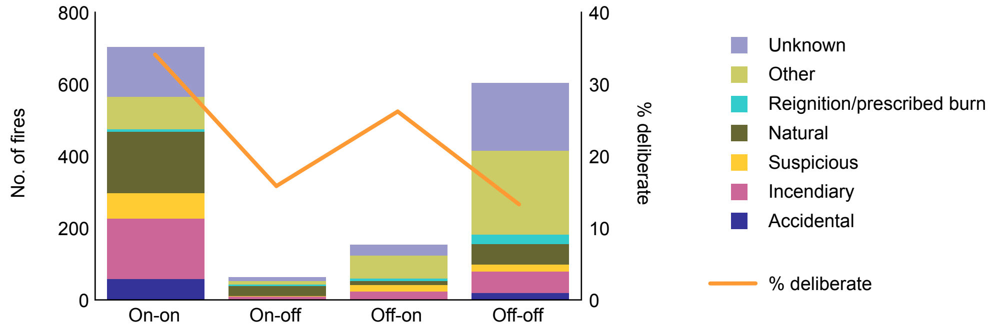
Figure 76: Point of origin and suppression relative to park boundaries (percent)



Note: On_on means Fire started on SADEH reserve and was contained on SADEH reserve; on_off means the fire started on SADEH reserve and burned into other land; off_on means fire started off SADEH reserve and burned into SADEH reserve; off_off means fire started off SADEH reserve and was contained off SADEH lands; PB refers to a prescribed burn, and on and off, to the location of that burn

Source: AIC SADEH 1975–76 to 2003–04 [computer file]

Figure 77: Cause of fires within specific on-off park categories



Source: AIC SADEH 1975–76 to 2003–04 [computer file]

Timing

The timing of fires was analysed by week of the year and day of the week.

Week of the year

Overall, the distribution of SADEH-attended fires strongly mirrors the trend observed for SACFS fires. Notably, the numbers of fires increase markedly from mid September onwards, concomitant with decreasing spring rainfall, reach a maximum early in the new year, before decreasing to negligible levels by the middle of the year. However, the timing of fires was strongly cause-specific, with the increase in the number of non-deliberate fires preceding the increase in deliberate fires (Figure 78). This principally reflects contributions from natural and other fire causes.

Large spikes in the number of natural fires are evident at week 44 (early November) and week 48 (early December), with smaller numbers of fires occurring throughout the remainder of summer (Figure 79). The spike at week 44 principally arises from fires during 2002–03 when 21 fires were caused by lightning strikes in a single week. In contrast, the spike at week 48 reflects a higher number of natural fires over a number of years. The observed distribution for natural fires is strongly dominated by exceptionally dry years, like 2002–03, and hence may not reflect the pattern expected in 'normal' years.

In contrast to natural fires, the number of deliberate fires started to increase in early November, and had peaked by the middle to late December. The number of deliberate fires remained elevated until mid to late March (Figure 78). An additional spike is evident at week 15, which may coincident with the Easter break/ school holidays.

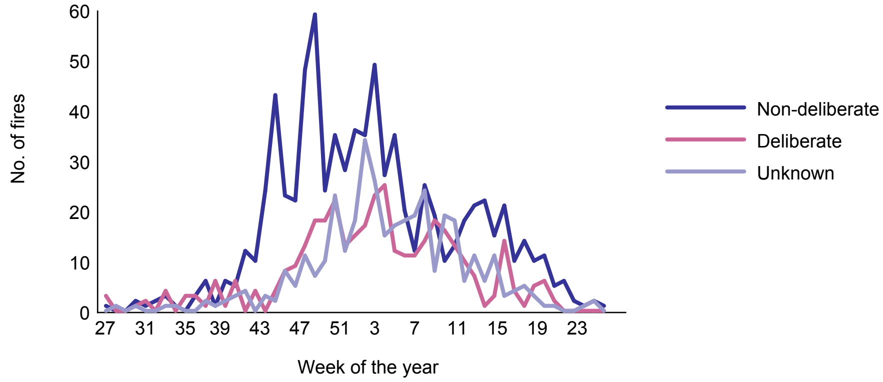
Day of the week

There no evidence to indicate that a fire of any particular cause was more likely to occur on one day of the week than another, including deliberate causes (Figure 80).

Time of the day

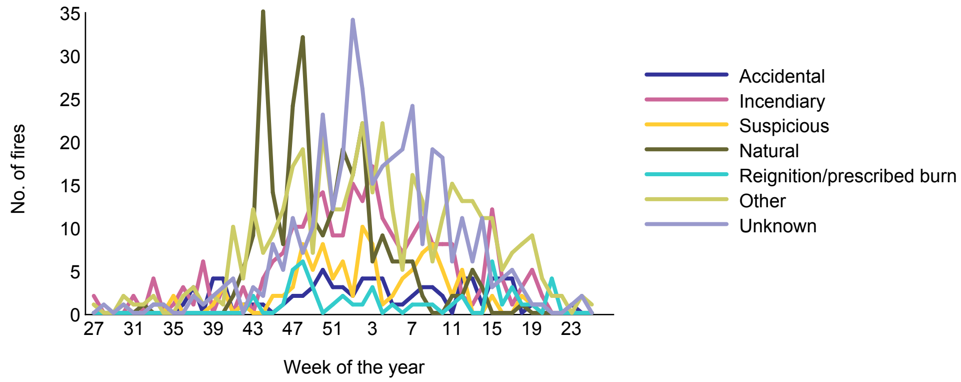
No information was available about the detection time of SADEH fires.

Figure 78: Cause by week



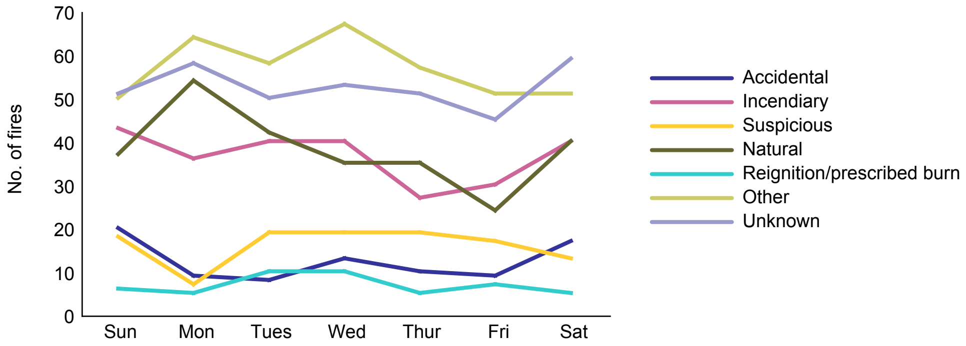
Source: AIC SADEH 1975–76 to 2003–04 [computer file]

Figure 79: Cause by week (number)



Source: AIC SADEH 1975–76 to 2003–04 [computer file]

Figure 80: Cause by day (number)



Source: AIC SADEH 1975–76 to 2003–04 [computer file]

Area burned

Data pertaining to the area burned was only available for the three years – 2001–02 to 2003–04. Over 700,000 ha burned during this period, but the statistics are dominated by fires in 2002–03, when abnormally large areas were burned. Notably, 95 percent of the total area burned during the observation period occurred in 2002–03 (Figure 81).

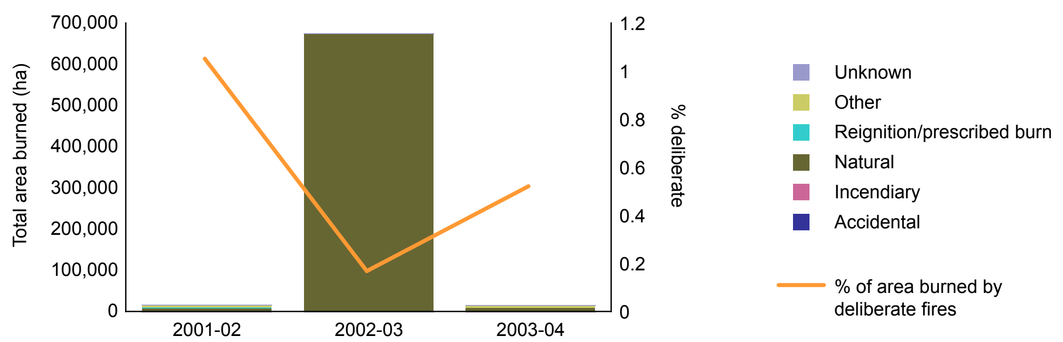
Overall, the majority of fires are small, and the number of fires decreased as the area size increased. Although this was observed for all causes, fires of different causes had very different size distributions. Largely shaped by events during 2002–03 there was a strong tendency for natural fires to be larger than fires of all other causes, with natural fires comprising an increasing proportion of successively larger area burned categories (Figure 82). Eight fires burned 1,000 ha or more during 2002–03. Of these, seven resulted from natural causes. One fire burned 600,000 ha. Another two fires (of 6,400 ha and 12,000 ha) occurred in Outback South Australia. Another 6,527 ha of land burned on Kangaroo Island, a 16,000-ha fire on the Eyre Peninsula, and two fires burned 28,000 ha and 1,500 ha in the Murraylands region.

Only five fires of non-natural causes exceeded 1,000 ha. One deliberate fire burned 1,000 ha. Another fire classified as deliberate resulted from reignition of a previous fire. Another three resulted from other causes. Overall, deliberate causes accounted for a decreasing proportion of fires as the size of the fires increased (Figure 82).

As large fires principally governed the total area burned, it is not surprising that 98 percent of the area burned in SADEH-attended fires were the result of natural causes (Figure 83). Incendiary fires accounted for only 0.2 percent of the total area burned. As noted however, the area burned statistics are dominated by the 2002–03 bushfire danger season, when unusually large fires resulted from natural causes. The value of 0.2 percent is unrealistic reflection of the area burned by deliberate fires, or their long-term relative impact on SADEH-managed lands.

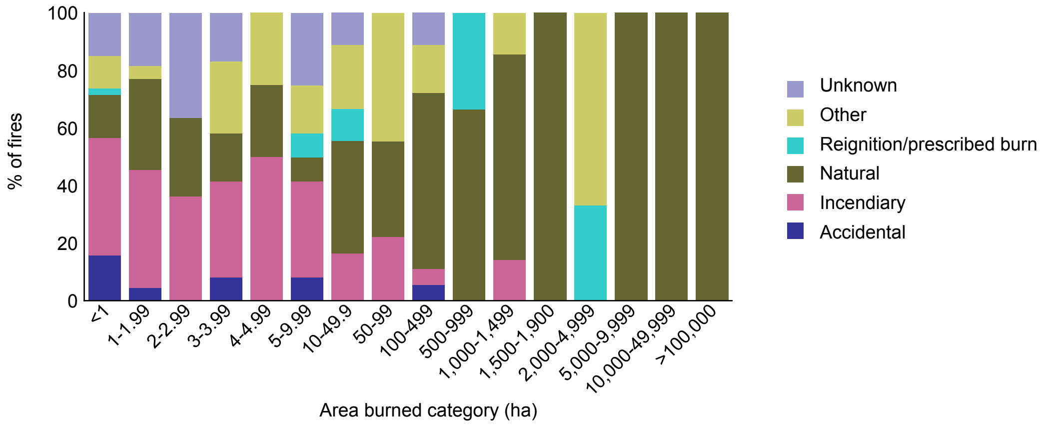
Overall, there was a tendency for the proportion of fires starting on, and being contained on, a SADEH reserve to account for a decreasing proportion of increasingly large fires (Figure 84). The notable exceptions were for the very large fires that presumably occurred on very large reserves in more remote South Australian locations. In contrast, fires started off reserves and contained off reserves accounted for higher proportions of moderately sized fires, as did fires that started on a SADEH reserve and subsequently spread to other lands. However, the overall number of such fires was very low.

Figure 81: Area burned by cause



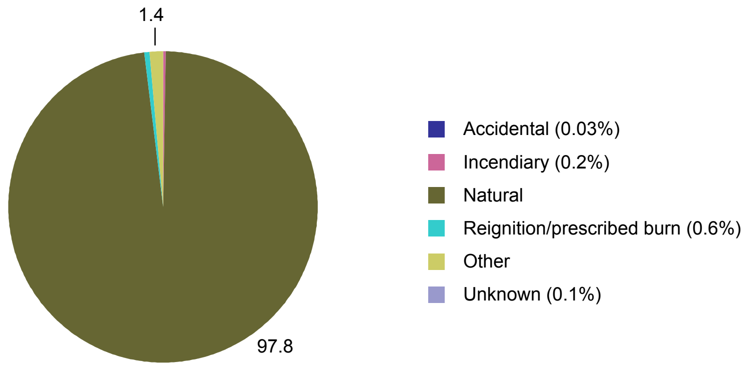
Source: AIC SADEH 1975–76 to 2003–04 [computer file]

Figure 82: Percentage of fires within each area burned category that resulted from each cause



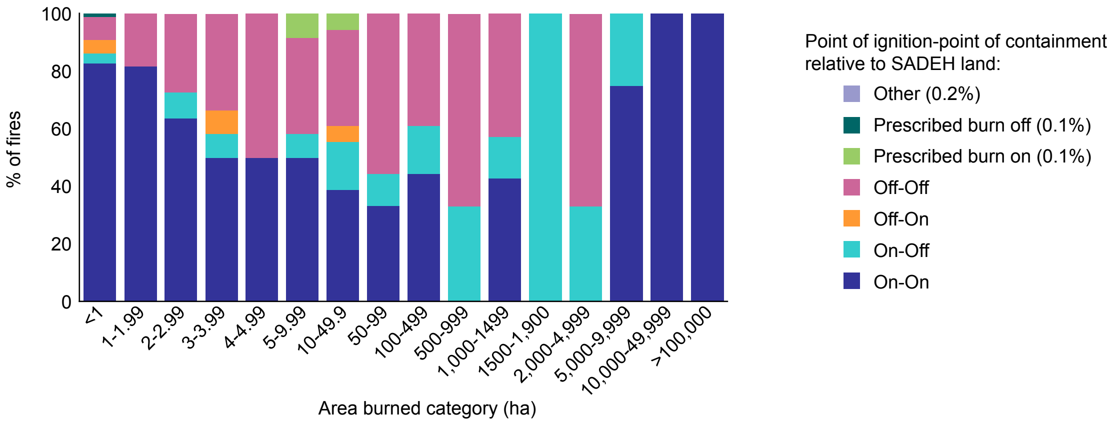
Source: AIC SADEH 1975–76 to 2003–04 [computer file]

Figure 83: Total area burned (percent)



Source: AIC SADEH 1975–76 to 2003–04 [computer file]

Figure 84: Area burned category by point or origin and containment/suppression



Source: AIC SADEH 1975–76 to 2003–04 [computer file]

Type of incident

As indicated in the overview, the SADEH is a land management agency. Hence, it is reasonable to assume that a high proportion of all fires attended could either genuinely be classified as a bushfires or had the potential, under adverse weather conditions, to develop into a bushfire. However, approximately three-quarters of all fires attended (where area was known) were less than 1 ha with almost 90 percent being less than 5 ha. Deliberate fires were on average smaller than accidental and natural fires.

Summary

There was an average of 3,200 landscape (vegetation) fires attended in South Australia every year from 2000–01 to 2005–06, with such fires typically comprising between 35 and 40 percent of all fires attended in the state (APC 2007). The overwhelming majority of vegetation fires are attended by the SAMFS and the SACFS, with the total number of incidents being evenly distributed between the two. Less than two percent of all vegetation fires were attended by SADEH, either within their reserves (50%) or on neighbouring property (50%).

Type of incident: Owing to differences in their jurisdictions and responsibilities, some differences are likely in the types of incidents attended by the three services, although this was difficult to illustrate based on the available data. For all agencies, there was a dominance of grassfires over other categories, with very a small proportion of all fires being forest fires

SAMFS: vegetation fires characterised by malicious activity in the area were primarily identified as grassfires (43%), small vegetation fires (36%) or other vegetation or outside fires (18%), for the interval from 1997–98 to 2005–06, although changes in the classification of fires indicate that many fires previously identified as grass fires are now classified as small vegetation fires or other vegetation or outside fire. Forest or wood fires (>1 ha) comprised 0.03% of fires attended

SACCFS: Approximately half (53%) of all the fires attended were grass or stubble fires, 38 percent were scrub and grass fires mixtures, with a further 7.1 percent being tree fires. Only 1.7 percent of vegetation fires were forest fires.

Cause: Incomplete data and a lack of internal and interagency consistency in causal categories hampered a rigorous evaluation of the causal data. Based on the available information, deliberate fires comprised:

- between 15 and 30 percent (estimate) of all vegetation fires attended by the SAMFS
- twenty percent (15.9% suspicious; 4.3% incendiary) of vegetation fires attended by the SACFS from 1997–98 to 2003–04
- thirty percent of fires attended by the SADEH.

Based on the available data, and reflecting the dominance of the SACFS and SAMFS in the fire statistics, it is estimated that approximately18 to 20 percent of all vegetation fires in South Australia were deliberate in origin.

Additional factors are summarised below:

- *Natural fires*: As observed elsewhere, the proportion of fires attended that were natural in origin varied markedly between agencies, being responsible for 30 percent of fires attended by SADEH (1999–00 to 2003–04 only), 12 percent of fires attended by SACFS and an unknown proportion of SAMFS fires. Based on the generally low rates of natural fires reported by metropolitan fire agencies, it is estimated that only about five percent of all vegetation fires in South Australia were natural in origin; that is 95 percent of all vegetation fires attended were human-caused.

- *Fires started by children*: Children were identified as being responsible for 4.7 percent of vegetation fires attended by the SAMFS as being associated with malicious activity, and 2.4 percent of all vegetation fires attended by the SACFS, with an average of 3.7 percent for the interval from 2000–01 to 2003–04. Children were identified in 3.1 percent of fires attended by SADEH. These statistics represent a minimum; actual incidences are likely to be somewhat higher, as the classification requires evidence of a child's involvement, for example being observed at the scene.
- *Smoking-related vegetation fires*: Two percent of malicious vegetation fires attended by the SAMFS were classified smoking-related. Actual incidences of smoking-related fires were probably markedly high given that the overwhelming majority of these fires are not identified as being associated with malicious activity. Smoking-related fires comprised between two and three percent of all vegetation fires attended by the SACFS each year, and 1.0 percent (category includes matches) of fires attended by the SADEH from 2000–01 to 2003–04.

Additional factors relevant to individual agencies are summarised below.

- *SAMFS*: 60 percent of malicious vegetation fires involved the use of an open flame or spark, of which half involved the use of matches. Twenty-six percent involved a hostile fire, 6.6 percent a fuel-powered object and 1.4 percent explosives or fireworks.
- *SACFS*: Of the 59 percent of cases where the specific ignition factor was identified (all fires causes), one-quarter related to burning off, with a further 10 percent involving harvesting or slashing, 12 percent being related to other machinery or vehicles, and 22 percent identified as resulting from other causes. Five percent of all deliberate fires related to burning off. This represented almost one fifth of all deliberate fires where the specific ignition factor was identified. Two-thirds of burnoffs that were classified as malicious were lit without a permit.
- *SADEH*: Neighbours burning off accounted for 4.2 percent of fires attended.

Location: Assuming that the distribution of malicious vegetation fires is representative of the distribution of vegetation fires attended by the SAMFS, and that the SAMFS, SACFS and SADEH attended 49.9, 48.3 and 1.8 percent of all vegetation fires respectively, it is estimated that 50 percent of all vegetation fires in South Australia occurred in the Adelaide region, seven percent each in the Flinders Ranges Adelaide Hills regions, six percent in the Limestone Coast region, five percent in the Eyre Peninsula regions, and three percent each in the Yorke Peninsula, Riverland and Murraylands regions. The Barossa and Clare Valleys, Kangaroo Island and Outback SA collectively only accounted for five percent of vegetation fires attended in SA. Not surprisingly, vastly different distributions were evident across agencies, as detailed below.

- *SAMFS*: 83 percent of all malicious vegetation fires attended by SAMFS occurred in the Adelaide region, with by far the greatest numbers being attended by the Elizabeth and Salisbury stations, followed somewhat distantly by Christie Downs, Angle Park and O'Halloran Hill. Ten percent of fires attended by SAMFS occurred in the Flinders Ranges region, with four percent in the Eyre Peninsula and two percent in the Riverland regions, being associated with major regional centres like Port Augusta, Port Pirie, Whyalla.
- *SACFS*: Fires attended by SACFS were more evenly distributed across the state, although high concentration were evident in the more highly populated regions, with the Adelaide, Adelaide Hills, Limestone Coast regions accounting for 17, 13 and 11 percent of all fires attended. A further 10 percent occurred on the Fleurieu Peninsula, seven percent on the Yorke Peninsula, six percent on the Eyre Peninsula.
- *SADEH*: 33 percent of all fires attended by SADEH occurred in the Adelaide region, with a further 20 percent occurring in the Adelaide Hills. Eleven percent of fires attended by SADEH occurred in the Limestone Coast region; with three to seven percent each being located in the Eyre Peninsula, Fleurieu Peninsula, Flinders Ranges, Kangaroo Island, Murrayland and Riverland regions.

Timing: The timing of vegetation fires is summarised by the week of the year, day of the week and the time of the day on which they occurred.

Week of the year: the overwhelming majority of all fires occurred between early November and mid April, coincident with the bushfire danger season. Some subtle differences were evident between years and between causes. Within the SACFS data there is clear evidence for a peak in burnoffs between mid-September and early December, and between mid April and mid May, just prior to and at the close of the bushfire danger period. Peaks in natural fires occurred in SACFS and SADEH data between early November and early February. However, high numbers of natural fires in November and to a lesser extent December was unusual, principally being a feature of 2002–03, a year associated with widespread drought. Incendiary and suspicious fires were high through the bushfire danger season, principally between November and mid April.

Day of the week: Overall, greater numbers of vegetation fires in South Australia occur on weekends than on weekdays, although the extent of this trend varied between agencies, between regions and depending on the cause, as illustrated below.

- **SAMFB**: 1.4 to 1.5 times more malicious vegetation fires occurred on Sunday and Saturday respectively than on the average weekday, being as high as 1.7 to 2.2 higher and 2.7 to 2.5 times higher on Sunday and Saturday as the weekday average in the Flinders Ranges and Eyre Peninsula regions. Vegetation fires in the Adelaide region were 40 percent more likely on both Sunday and Saturday.
- **SACFS**: 33 percent more fires (all causes) occurred on Saturday, but higher numbers of fires were not observed on Sunday compared with any other day of the week. Overall, deliberate causes were 36 percent higher on Sundays and 57 percent higher on Saturdays than on the weekday average, whereas more accidental fires occurred on Tuesday and Saturday than on other days of the week. Regional differences are noted; in Adelaide and Adelaide Hills regions, higher proportions of deliberate fires occurred on Saturday than on Sunday, whereas on the Fleurieu Peninsula the reverse prevailed.
- **SADEH**: no differences were evident based on by day of the week.

Time of the day: vegetation fires occurred varied marked based on cause, day of the week and region. The trends observed for the SAMFS and SACFS are summarised below.

SAMFS: malicious vegetation fires define two peaks, with maximums occurring at 5 pm to 6 pm and 10 pm to 11 pm. Rates were variable at local scale; commonly between 50 and 70 percent of all malicious vegetation fires occurred between 6 pm and 6 am for most metropolitan stations, with commonly between 20 and 35 percent occurring between midnight and 6 am. Lower proportions of fires occurred at night in those locations recording the highest numbers of fires overall. Higher numbers and proportions of nighttime fires were evident on Friday night–Saturday morning and Saturday night-Sunday morning. A high number and proportion of fires in major regional urban centres also occurred at night; 48 to 54 percent of all malicious vegetation fires in the Flinders Ranges, Eyre Peninsula and Riverland regions occurred between 6 pm and 6 am.

SACFS: most fires occurred between 10 am and 8 pm, irrespective of cause. However, non-deliberate fire frequencies peaked between 2 and 3 pm whereas peak numbers of deliberate fires occurred between 3 and 5 pm, overlapping with the peak in child fire s that occurred from 4 to 6 pm. Higher proportions of deliberate than non-deliberate fires, occurred at night; 43 percent of all deliberate fires occurred between 6 pm and 6 am, with 26 percent of deliberate fires occurring between midnight and 6 am. Increases in night fires were most evident for Friday night–Saturday morning and Saturday night–Sunday morning. However, the tendency for deliberate fires at night, particularly between midnight and 6 am, varied markedly by location, being higher in the Adelaide region but comparatively lower in many less populated regional areas. Children lit most fires between 4 and 6 pm.

Educational facilities: SAMFS data for vegetation fires at educational facilities indicate that the majority occur outside of schools hours (including the period in which one might expect children to be making their way home); 1.6 times more occurred on Sunday and 2.2 times more likely to occur on Saturday than on the average weekday; high numbers were lit between 3 pm and 6 pm but in many cases this was on weekends rather than weekdays; approximately 60 percent (where time was recorded) occurred between 6 pm and 8 am.

Area burned: Overall, fire frequency decreased with increasing size, although it is evident that fires attended by the SACFS were on average smaller than those reported by the SADEH, reflecting differences in cause, accessibility etc. There is clear evidence that natural fires accounted for an increasing proportion of fires attended by the SADEH as fire size increased. This is evident to a lesser extent in the SAACFS data, although in that case, accidental and more rarely deliberate fires were also a contributor. Large fire events are the overwhelming contributor to any figures regarding the total area burned as outlined below.

SADEH records indicate seven million hectares was burned from 2001–02 to 2003–04, of which 98 percent was burned by large natural fires during 2002–03. During the same interval incendiary fires burned 1,339 ha, being responsible for just 0.2 percent of the total area burned.

SACFS: 144,686 ha were burned from 1997–98 to 2003–04. Of this 31 percent resulted from accidental causes, 28 percent from natural origins, and 32 percent from fires of unknown causes. Less than six percent of the total area burned was the result of fires of incendiary or suspicious origin. For the SACFS, large areas were burned by natural fires in both 1997–98 and in 2002–03. The greatest areas were burned by deliberate fires in 2000–01 and 2002–03.

Sources of background information

ABS 2006. *Australian demographic statistics*. ABS cat. no. 3101.0. http://www.abs.gov.au/ausstats/abs@.nsf/cat/3101.0

ABS 2005a. *Population by age and sex, South Australia*. ABS cat. no. 3235.4.55.001. http://www.abs.gov.au/ausstats/abs@.nsf/cat/3235.4.55.001

ABS 2005b. *Tourism region maps and concordance riles, Australia, 2005*. ABS cat. no. 9503.0.55.001. http://www.abs.gov.au/ausstats/abs@.nsf/cat/9503.0.55.001

Australia. Department of Environment and Heritage 2001a. *Land use: South Australia*. Accessed through: http://audit.deh.gov.au/ANRA/atlas_home.cfm

Australia. Department of Environment and Heritage 2001b. *Native vegetation types and extent: South Australia*. Accessed through: http://audit.deh.gov.au/ANRA/atlas_home.cfm

Australian Bureau of Meteorology 2007a. *Average minimum and maximum temperature maps: South Australia*. Accessed through: http://www.bom.gov.au/climate/map/temperature/IDCJCM0005_temperature.shtml

Australian Bureau of Meteorology 2007b. *Average rainfall, annual: South Australia*. Accessed through: http://www.bom.gov.au/cgi-bin/climate/cgi_bin_scripts/annual-monthly-rainfall.cgi

Australian Bureau of Meteorology 2007c. *Fire seasons in Australia*. Accessed through: http://www.bom.gov.au/climate/c20thc/fire.shtml

CFS 2005a. Black Tuesday special report. *Volunteer 111*. http://www.cfs.org.au/about/pdf/95672%20CFS.pdf

CFS 2005b. *Firefront* 28. http://www.cfs.org.au/about/pdf/01%202005%20FIREFRONT.pdf

CFS 2005c. *SA Country Fire Service strategic directions 2005–2007*. http://www.cfs.org.au/about/pdf/CFS%20Strategic%20Directions%202005-07.pdf

DSE 2007. *Fire and other emergencies: Ash Wednesday 1983*. http://www.dse.vic.gov.au/dse/nrenfoe.nsf/childdocs/-D79E4FB0C437E1B6CA256DA60008B9EF-7157D5E68CDC2002CA256DAB0027ECA3?open

Ellis S, Kanowski P & Whelan R 2004. *National Inquiry into Bushfire Mitigation and Management*. Canberra: Commonwealth of Australia. http://www.coagbushfireenquiry.gov.au/findings.htm

EMA 2006a. *EMA disasters database: Adelaide and Environs, SA: bushfire, 1955*. http://www.ema.gov.au/ema/emadisasters.nsf/c85916e930b93d50ca256d050020cb1f/b1316e066eea4d3eca256d3300057c47?OpenDocument

EMA 2006b. *EMA disasters database: Southern Victoria and SA: bushfires 1983* . http://www.ema.gov.au/ema/emadisasters.nsf/c85916e930b93d50ca256d050020cb1f/76b9d4d54b20e8ffca256d3300057bd4?OpenDocument

Lindesay J 2003. Fire and climate in Australia, in Cary G, Lindenmayer D & Dovers S (eds), *Australia burning: fire ecology, policy and management issues*. Melbourne : CSIRO Publishing.

South Australia Central 2007. *Natural hazards*. http://www.atlas.sa.gov.au/index.cfm?objectId=2FDE8C68-1034-5339-FF888DD59140759F

Tasmania

Contents

The first part of this chapter provides **contextual information** on Tasmania, including basic information about its climate, geography, land use and population. It also provides an outline of the bushfire regimes, historically important bushfire events, and overview of fire services in Tasmania. The second part represents an **analysis of data** provided by the Tasmanian Fire Service. Although the Tasmania Fire Service attends many types of fire incidents, this analysis exclusively refers to vegetation fires, unless otherwise indicated.

For an explanation of the key terms, limitations and methodology refer to the introduction, glossary and methodology chapters.

Introduction

The state of Tasmania comprises a group of islands to the south of Victoria. It is separated from the mainland by the 240 km wide (on average) Bass Straight. Tasmania is bounded by the Southern Ocean to the south and west and by the Tasman Sea on the east. The island spans 296 km from north to south, and 315 km from east to west at its greatest extent.

Geography

The western half of Tasmania is dominated by a rugged mountain range that extends from the southwest coast to further inland and northward (Figure 1). This mountain range reaches approximately 1,600 m at its highest point. A plateau that was largely shaped by glacial activity during the last ice age dominates the central west. This region has numerous lakes and represents the starting point for many of Tasmania's rivers, including the Derwent, which flows southeast to Hobart; the Esk, Tamar and Mersery, which all flow north; and the Franklin and Gordon Rivers, which flow west. The eastern half of the state is generally lower in altitude and has lower relief, although there are several notable mountain ranges in the east.

Figure 1: Map of Tasmania

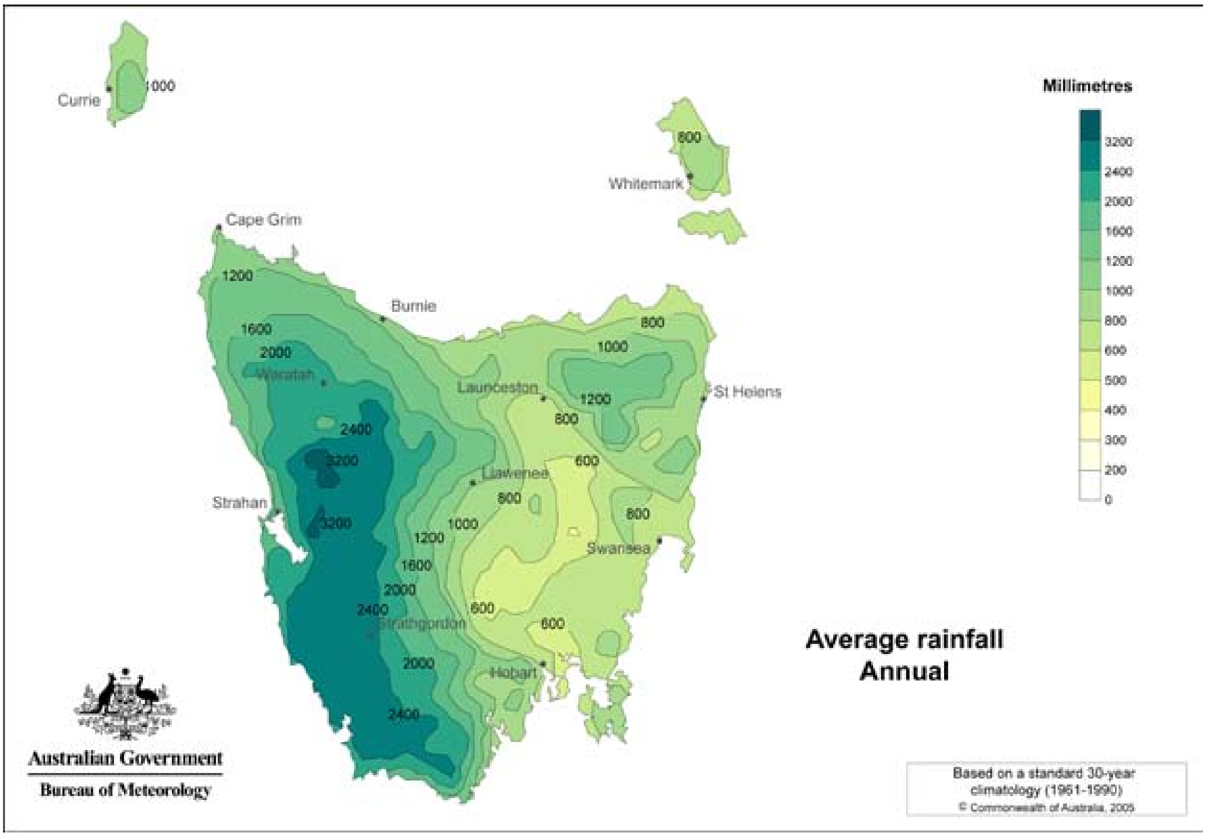
Climate

Overall, Tasmania is the coolest and wettest of Australia's states. At latitude 42° south, Tasmania lies directly in the path of the Roaring Forties, a band of strong winds that encircles the Earth. In winter the movement of cold fronts from west to east across the state largely shape Tasmania's climate, as cold air masses move from Antarctica toward the equator. Cold fronts have less influence on Tasmania's weather in summer as a band of high pressure pushes them further south. During an average week Tasmania experiences extremely variable fluctuations in both temperature and wind speed.

Tasmania experiences a temperate climate with four distinct seasons. Summer days are typically warm and sunny and are characterised by mild evenings. Thunderstorms commonly occur early in the season and temperatures can reach up to 35°C, but in general will be between 20 and 30°C. Tasmania's classic autumn features clear cool days and very cool to frosty nights, during which deciduous trees display autumn colours and lose their leaves. Winters are characterised by sudden storms, shorter daylight hours and snow on the higher peaks. Winter temperatures may reach lows of –10°C in the highlands, but coastal areas rarely go below freezing (Australian Bureau of Meteorology 2007a).

The southwest has exceptionally high rainfall (2400 mm; Figure 2), owing to precipitation from moisture-laden air masses, cooling as it passes over the central plateau. The ensuing rain shadow effect, results in warmer and drier conditions on the east coast. Hobart, located in the southeast, has an annual average rainfall of just 625 mm (Australian Bureau of Meteorology 2007b).

Figure 2: Average annual rainfall for Tasmania



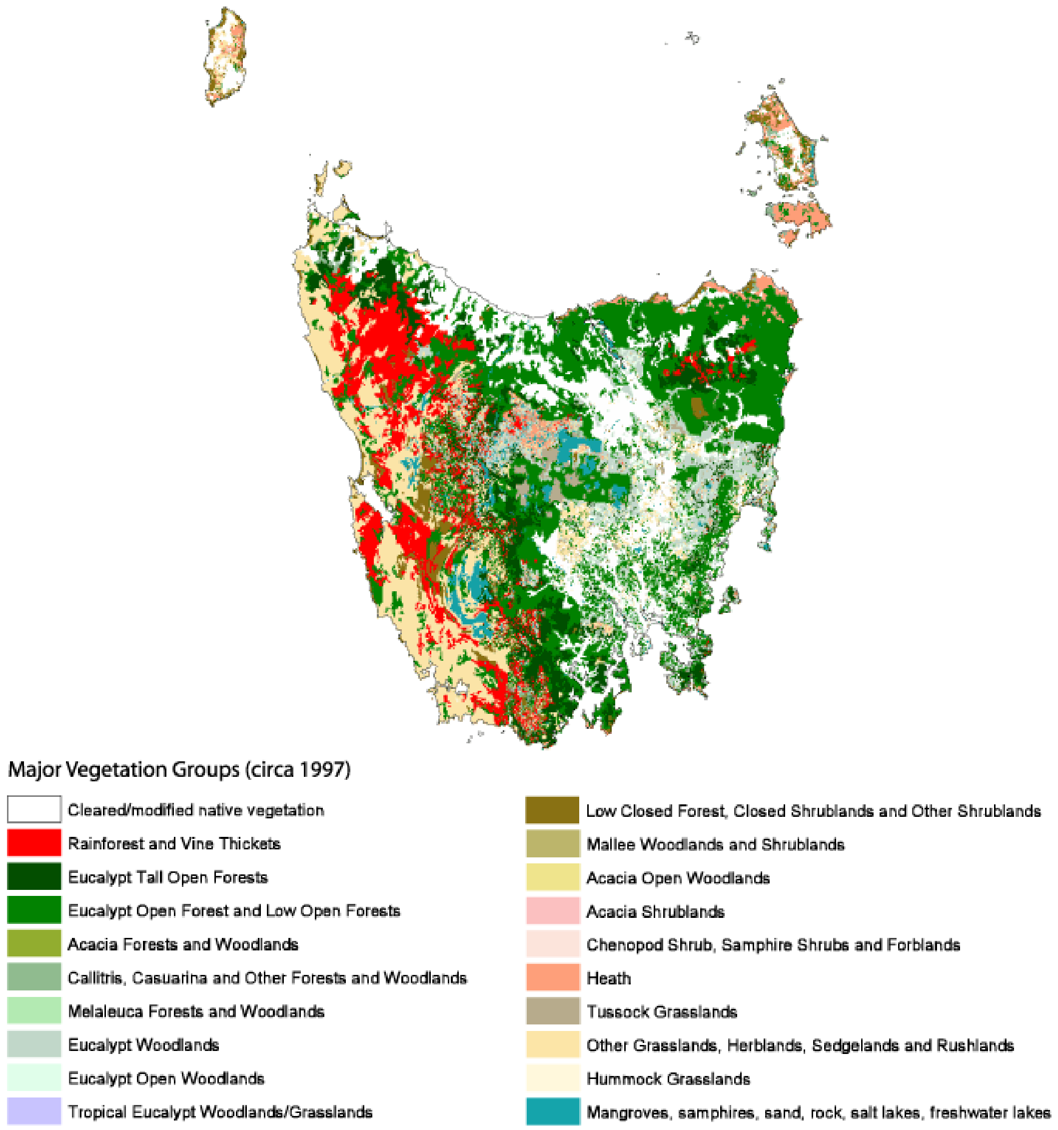
Source: Australian Bureau of Meteorology 2007b

Native vegetation

Vegetation in Tasmania is exceptionally diverse including tall evergreen Eucalypt forests, alpine heathlands and large areas of cool temperate rainforests and moorlands. Many species of flora are unique to Tasmania, and in many cases show greater similarities with species in South America and New Zealand than in mainland Australia species.

Eucalypt tall open forests, which often rise to 100 m, eucalypt open forest and low open forest dominate the north and east, although much of the central east and northwest have been modified by, or cleared for, agriculture (Figure 3). Rainforests and vine thickets are abundant in the wetter parts of Tasmania, namely on the west coast and to a lesser extent the northeast. The west coast also contains abundant grasslands, closed shrublands, some Eucalypt forests and small areas of heath. Grasslands, including tussock grassland also occur throughout the Central Highlands, and much of the northwest. Extensive heaths are found along the northern coast of eastern Tasmania in on major neighbouring islands (Australia. Department of Environment and Heritage 2001b).

Figure 3: Major vegetation groups (c. 1997)

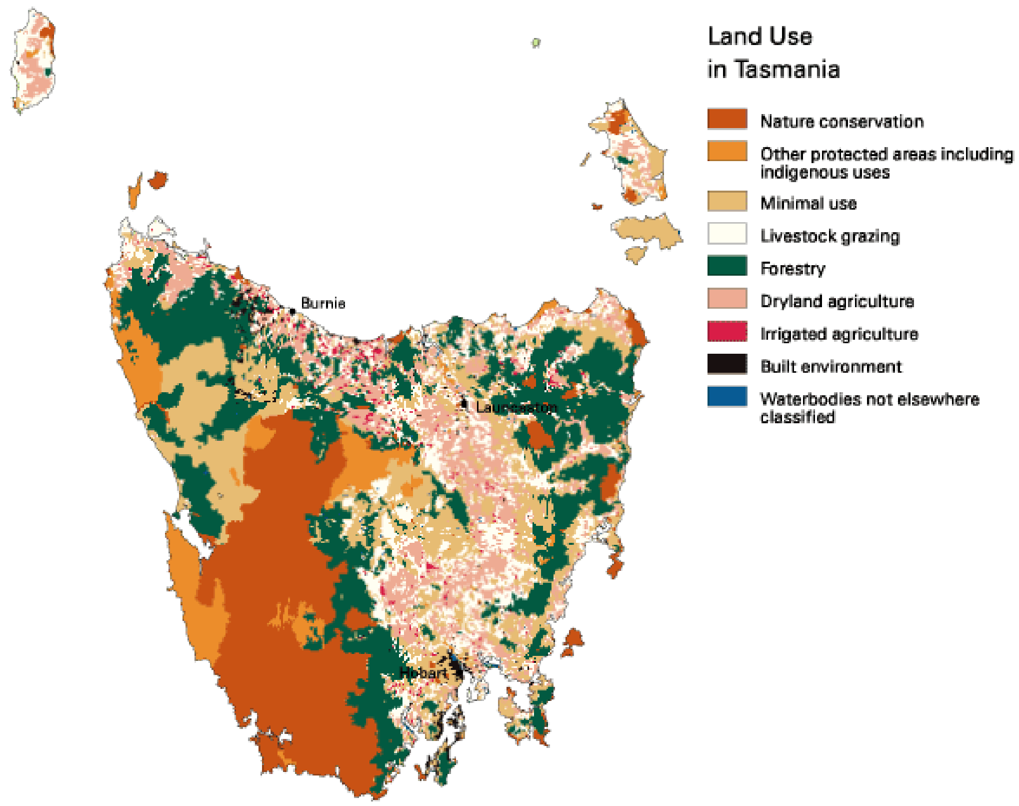


Source: Australia. Department of Environment and Heritage 2001b

Land use

In 1996–97, commercial forestry was the largest single land use in Tasmania, covering around 24 percent of the state (Figure 4). This mainly occurred in native hardwood forests, though there are increasing areas of plantations of both exotic softwoods and native hardwoods. Collectively, nature conservation (21%), which mostly occurs in national parks, and minimal use areas (21%), which largely consist of remnant vegetation cover, accounted for almost half the state. Tasmania has the highest density of land preserved in reserves, national parks and World Heritage Sites of any state in Australia. The overwhelming majority of these sites are located in the southwest. Dryland agriculture, interspersed with livestock grazing and isolated patches of irrigated agriculture, occurs through the central north–south band of the island, along the northern margin, and to a lesser extent in the east. Collectively, agriculture occurs on just over one-quarter of Tasmania (Australia. Department of Environment and Heritage 2001a).

Figure 4: Land use (c. 1996–97)



Source: Australia. Department of Environment and Heritage 2001a

Population

Tasmania's population, as of 30 June 2006, was 488,900, accounting for just 2.4 percent of the country's population (ABS 2006). The population is roughly equally divided between north and south. Approximately 42 percent of the state population lives in Hobart statistical subdivision. Major regional centres in the north include Launceston, Burnie and Devonport. Launceston and Burnie statistical divisions accounted for 21 and 16 percent of the state's population in 2005 (ABS 2005a).

The median age of the resident population, as of 30 June 2005, was 38.7; 2.1 years higher than the national average (ABS 2005a). The highest median age was in the Southern statistical subdivision (40.6

years), followed by Mersey–Lyell (39.2 years), Northern (38.5 years) and Greater Hobart (38.2 years). Nevertheless, the highest proportion of people aged 0 to 14 live in the Southern (21.0%), Mersey–Lyell (20.4%), Northern (20.1%) and Greater Hobart (19.3%) statistical subdivisions. Local government areas with the lowest median ages and the highest proportion of children aged 0 to 14 years included Brighton (31.5 years), West Coast (36.1 years) and Circular Head (36.8 years).

Bushfire regimes

Bushfires in Tasmania are most commonly associated with dry conditions during summer and autumn. Bushfires may occur from November to mid May, although the exact timing of peak bushfire danger varies between seasons, depending on the rainfall distribution over late spring to autumn. Large differences in rainfall distribution across the state affect not only the bushfire regimes, but also the susceptibility of the vegetation to fire. The wetter areas of the southwest may rarely experience fire, because it is only under extreme drought conditions that vegetation dries sufficiently to allow fires to spread. Areas in the north and east (excluding some around Ben Lomond) receive lower rainfall and are more prone to bushfires under hot, dry summer–autumn conditions.

Although Tasmania is not renowned for bushfires, it is periodically vulnerable because:

- much of the state is vegetated, which poses inherent difficulties for fire suppression
- it represents one of the least urbanised states in Australia, with the population spread over much of the east and north of the state
- high rainfall–low evaporative conditions give rise to abundant vegetative growth and high fuel loads; managing fuel loads may be difficult owing to disruptions from intermittent rains during spring and early summer
- extreme fire conditions are not uncommon during seasons dominated by drought, but equally may occur after a short period of extreme bushfire weather that follows generally dry conditions
- fires in certain parts of the state may have devastating environmental impacts, as many of the species in the generally wetter regions (particularly southwest) are fire sensitive, being ill equipped to survive fire events (Tasmania Parks and Wildlife 2006).

Bushfire history

The most adverse bushfire events and seasons in Tasmania are summarised in Table 1. The devastating fires of 1967 are discussed in detail below.

1967: Black Tuesday – 7 February – Wet conditions in southeastern Tasmania in late winter late and spring were followed by a period of exceptionally dry conditions – beginning in November – resulting in the curing of the luxuriant growth that the previous wet weather had promoted. Although January was not particularly hot, there were extreme temperates and low humidity on the four days leading up to Black Tuesday. During this time numerous fires burned to the north of Hobart. Exceptionally hot conditions, low humidity and very strong northwesterly winds – fire index of 96 – brought suburban Hobart and neighbouring settlements under direct attack from bushfires, with devastating effect. The fires resulted in 62 deaths and 900 injuries; as well as the deaths of 500 horses, 1,350 cattle, 60,000 sheep, 24,000 chickens, 600 pigs, and other animals. Over 3,000 buildings were destroyed, including 1,293 homes and 128 other major buildings (factories, churches, schools, post offices etc.). Also lost were 80 bridges and thousands of power poles, 1,500 vehicles, and 5,400 km of farm fences. A total of 265,000 ha were burned, including 20 percent of the state's fruit crop as well as other crops, pasture and forest. The total estimated cost was approximately $45 million (1967 values). Of the 110 fires that burned on 7 February 1967, only 22 were accidental. Some had been deliberate lit for back burning despite the extreme weather conditions at the time (EMA 2006, Ellis, Kanowski & Whelan 2004).

Table 1: Fire history of Tasmania

Date	No. of deaths	Area of fire (ha)	Losses	Location(s)
1897, 1898, 1912				Well-timbered western part of state, northwest coastal region; Huon, Channel, Hobart and New Norfolk districts
1913–14 season			Orchards, buildings, stock	Mount Wellington, Huon
1920				Northwest
1921				Northeast
1927				Southeastern districts, Tasman Peninsula
1933–34 season				Florentine, Derwent Valley, northwest forests and west coast
1939		9,600	Forests, orchards, pastures	Huon, Derwent Valley, west coast, King Island
1940		16,000		Hobart
1945–46 season				Mount Wellington
1951			Hundreds of thousands of metres of marketable timber	Huon
1960–61 season				Parattah, Perth and through Midlands
1963–64 season			Pine plantations	Cambridge, Hobart, Snug, north coast
1966–67 season	62	264,270	Greater than 1,400 houses, 128 major buildings, 1,500 vehicles, 50,000 sheep, 1,350 cattle, 1,000 pigs, 4800 km of fences	Southeast, Hobart
1977				Zeehan
1980		40,000		Launceston, Hobart, Zeehan
1981			6 houses	Pelverata, Bonnet Hill
1982	1	>40,000		Launceston, Hobart, Broadmarsh
1998		3,000	6 houses	Hobart's southern suburbs
2003		41,000		

Source: Ellis, Kanowski & Whelan 2004

Fire services

Three major agencies provide fire services in South Australia. They are the Tasmania Fire Service, Tasmania Parks and Wildlife Service and Forestry Tasmania.

The **Tasmanian Fire Service** attends a diverse range of emergencies including bushfires, structural and vehicle fires, hazardous material incidents, urban search and rescue and high angle rescue, as well as other types of incidents. It incorporates over 230 fire brigades across Tasmania and its islands. Approximately 250 career firefighters and approximately 4,800 volunteer firefighters provide coverage for most urban and rural districts (Ellis, Kanowski & Whelan 2004, *see also* http://www.fire.tas.gov.au).

The **Tasmanian Parks and Wildlife Service** is responsible for managing national parks and other conservation reserves (Ellis, Kanowski & Whelan 2004, *see also* http://www.parks.tas.gov.au/manage/fire/index).

Forestry Tasmania is responsible for managing the state forests (Ellis, Kanowski & Whelan 2004, *see also* http://www.forestrytas.com.au/forestrytas).

The following analysis is based on vegetation fires attended by the Tasmanian Fire Service from 1999–2000 until 23 November 2004. The database provided complete coverage for all urban and rural areas that lie outside of national parks and state forests (approximately half the state). However, the Tasmanian Fire Service has mutual aid arrangements with Tasmanian National Parks and Wildlife and Forestry Tasmania, to ensure major bushfires are adequately resourced and managed. Hence, at least some, and presumably the largest, fires that occurred in national parks and state forests were recorded within the Tasmanian Fire Service database.

Tasmanian Fire Service analysis

Background about the TFS dataset and its analysis

Important information about the TFS dataset and the methodology used to analyse it is summarised as:

- Data were sourced from the Tasmanian Fire Service (TFS).
- The data provided included vegetation (wildfires) fires only.
- The dataset included fires from 1999–2000 until 23 November 2004.
- The database used Australian Incident Reporting System (AIRS) variables and codes.
- The cause of fires was based on the ignition factor variable.
- Deliberate vegetation fires refer to all vegetation fires classified as incendiary (AIRS ignition factor code 110 or 120) or suspicious (AIRS ignition factor code 210 or 220). The majority of fires were labelled as incendiary; only two vegetation fires were classified as suspicious.
- Natural fires refer to all fires where the ignition factor codes were 800 to 890, that is, any fires that resulted from any natural condition or event. The breakdown of TFS was; high wind 57 percent, high water including floods 0.5 percent, lightning 24 percent, and fires resulting from any other natural condition 19 percent.
- Information about the form of heat of ignition was not included within the supplied database
- Smoking-related fires included all fires where the ignition factor = abandoned or discarded materials (Ignition Factor code 310).
- All fires attributed to children and discussed in the text were classified accidental in origin. This may only be a small subset of fires started by children, as malicious fires started by children are incorporated in the incendiary or suspicious categories and cannot be identified. Information about the age of the child was supplied.
- The regions used in the TFS analysis were based on Australian Bureau of Statistics (ABS 2005b) tourism regions. The ABS defines tourism region based on smaller statistical areas so ABS tourism regions potentially crosscut suburbs and postcodes. In this study, assignation was based on the highest levels of concordance between postcodes and suburbs and tourism regions. Hence, there is not an exact correspondence between tourism regions used in this analysis and ABS tourism regions.
- The dataset included information about the area burned.
- No information was available regarding fire restrictions or fire danger index.

For more detail about these methodologies see the methodology chapter.

Overview

Fires attended by the TFS can be summarised as follows:

- The TFS attended 13,083 vegetation fires from 1999–2000 until 23 November 2004. Yearly fluctuations in fires numbers were small, with fire numbers varying between a minimum of 2,175 in 2003–04 and a maximum of 2,813 in 2002–03 (Figure 5). Although the peak number of fires occurred during 2002–03, the number of fires during this year did not substantially exceed those recorded in 1999–2000 or 2000–01.
- Increased cooperation between fire agencies, police, emergency services agencies and the media and increased engagement with local communities was a feature of 2002–03. The fire service's message was that communities and individuals needed to be more responsible in protecting their own properties (Ellis, Kanowski & Whelan 2004). It is unclear to what extent increased community awareness affected total and deliberate vegetation fire frequencies in 2002–03 or subsequent years.
- TFS fires occurred in a diverse range of environments including urban, rural and conservation areas; the majority were within or in close proximity to urban environments.
- Almost three-quarters of fires were grassfires, with approximately 10 percent occurring in forest or woodland settings.
- Thirty-six percent of all vegetation fires were deliberately lit.
- Approximately 190,000 ha were burned in vegetation fires in Tasmania during the observation period. The majority was grassland in regional areas. Deliberate causes were attributed to 6.6 percent of the total area burned.

Cause

Incendiary causes were singly the largest 'known' cause of TFS-attended vegetation fires, accounting for 36.3 percent of all fires (Figure 6). Only two fires (0.02%) were classified as suspicious. Hence, collectively, deliberate causes (incendiary and suspicious) accounted for 36.3 percent of all fires. Accidental causes accounted for a further 23 percent of all fires, with 4 percent resulting from reignition/exposure, 1.7 percent from natural causes, and another 3 percent result from other causes. The cause of 31.6 percent of all fires was unknown. Hence, deliberate causes accounted for 53 percent of known causes.

The proportion of deliberate fires increased from a low of 26 percent in 1999–2000 to approximately 40 percent in the years incorporating 2001–02 to 2003–04 (Figure 7), although lower rates of deliberate fires in 1999–2000 and 2000–01 may be obscured by the overall lower rates of causal attribution. The relative proportion of fires started by other causes remained comparatively stable over the five-year period.

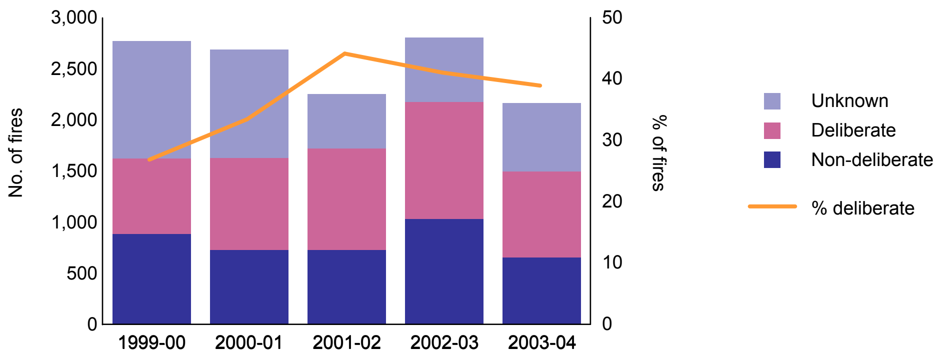
Specific ignition factors

Ignition factor: Due to the structure of data available, it is not possible to attain more specific information about the ignition factors involved in deliberate fires. Of non-deliberate fires, the majority arose from misuse of heat of ignition and 'other' factors (Figure 8). Most fires within the 'other' category resulted from reignition (43%), vehicle fires (24%), and other ignition factors, not further classified (31%). Comparatively few fires resulted from mechanical causes (0.9%) or operational deficiencies (1.4%). Little temporal variation occurred in the relative contributions of individual ignition factor types at a gross scale (Figure 9).

Child and adolescent fires: Approximately 1.3 percent (n=172) of all vegetation fires the TFS attended were attributed to children younger than 16 years of age playing. This is unlikely, however, to reflect the total number of fires attributed to or started by children. All fires that are malicious in origin are classified as incendiary or suspicious within the AIRS database, and cannot be further delineated. Moreover, in order for a fire to be attributed to a child, it requires evidence that a child was involved, for example, being sighted near the fire at the time it occurred. Hence, the actual number of fires attributed to children is likely to be substantially higher than has been observed. The number of non-deliberate child fires increased with age, with 0 to 5 year-olds accounting for three percent of fires and 13 to 16 year-olds 58 percent of fires (Figure 10).

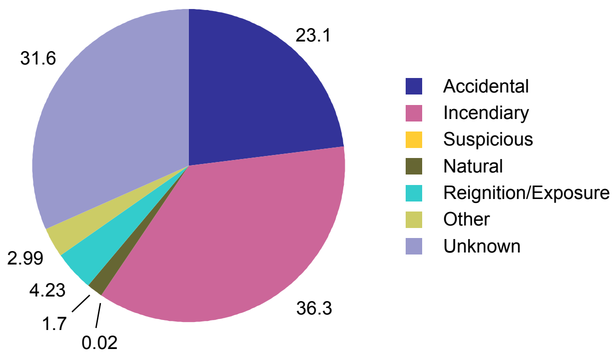
Smoking-related fires: Smoking-related fires accounted for 3 percent (n=403) of vegetation fires the TFS attended. This is equivalent to the proportion of cigarette-fires reported for rural or land management agencies in other jurisdictions, but is generally lower than that recorded by most urban-based brigades. These lower rates may in part reflect the fact that for the TFS smoking-related fires only refer to fires where the ignition factor code was 'abandoned and discarded materials'. Evidence from other jurisdictions indicates that such fires form a subset of smoking-related fires and their definition is based on 'form of heat of ignition' factor codes. This is because in the latter definition fires are also variably classified as 'misuse of heat of ignition', incendiary, etc. within the ignition factor variable.

Figure 5: Cause of fires each year



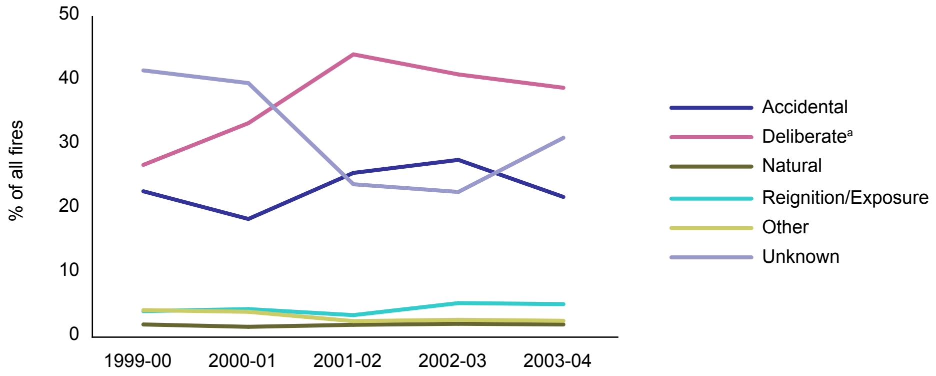
Source: TFS 1999–2000 to 2003–04 [computer file]

Figure 6: Fire cause (percent)



Source: TFS 1999–2000 to November 2004 [computer file]

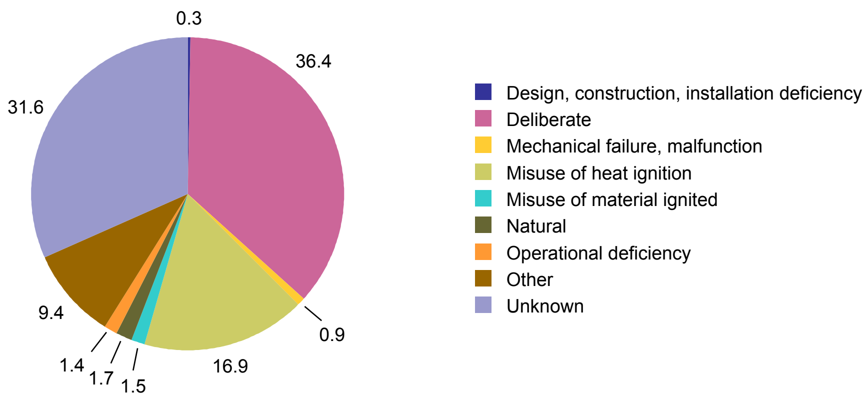
Figure 7: Cause of fire by year (percent)



a: in this, and all subsequent relevant figures, incendiary and suspicious fires are combined to yield a deliberate category.

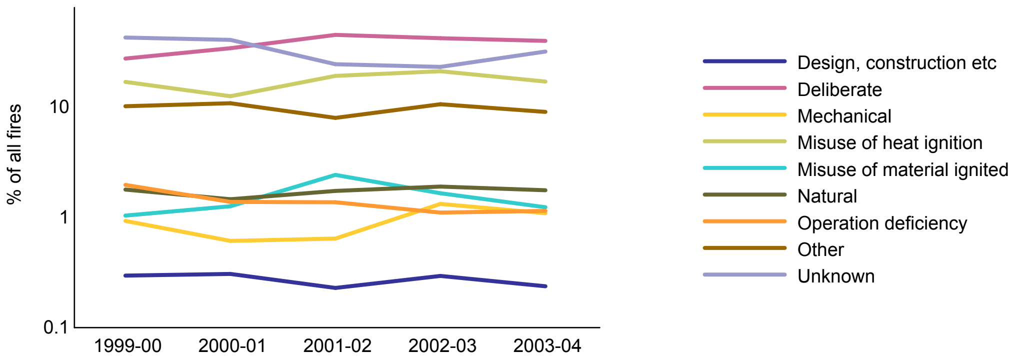
Source: TFS 1999–2000 to 2003–04 [computer file]

Figure 8: Ignition factor (percent)



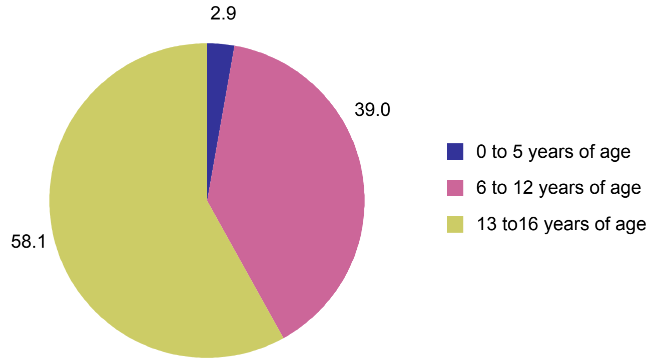
Source: TFS 1999–2000 to November 2004 [computer file]

Figure 9: Ignition factor by year (percent)



Source: TFS 1999–2000 to 2003–04 [computer file]

Figure 10: Non-deliberate child vegetation fires by age (percent)



Source: TFS 1999–2000 to November 2004 [computer file]

Location

The location analysis incorporates information about the distribution of fires at a regional level, at a postcode and suburb level, as well as the distribution of fires across Tasmania relative to the distribution of the population.

Region

Fires the TFS attended were assigned to one of six tourism regions based on the postcode and suburb in which the fire occurred (Figure 11). The majority of all fires occurred in or near major urban centres, with 44 percent occurring within the Greater Hobart region (Figure 12). A further 17 percent occurred in the Greater Launceston region. The TFS attended comparatively few fires in the East Coast and West Coast regions.

The total number of deliberate vegetation fires strongly correlated with the total number of vegetation fires within each region (r = .98, p<.001). Nevertheless, some variation was evident in the percentage of deliberate vegetation fires in each region. The highest percentage of deliberate fires occurred in the Greater Launceston (47%) and Greater Hobart regions (48%). Fifty-nine percent of all deliberate vegetation fires the TFS attended occurred in Hobart. Twenty-three percent of all deliberate vegetation fires occurred in the Greater Launceston area.

Collectively, only 18 percent of vegetation fires that occurred outside the Greater Launceston and Greater Hobart regions were attributed to deliberate causes. The highest percentage of deliberate fires in regional Tasmania occurred in the West Coast (26% deliberate) and North West (25% deliberate) regions (Figure 12). Comparatively lower rates of deliberate fires occurred in the Northern region, a reflection of the high proportion of both accidental and unknown fires.

Approximately three-quarters of non-deliberate **child fires** occurred in the Greater Hobart region (Figure 13). Overall, there was a moderately strong correlation between the numbers of non-deliberate child fires and total vegetation fire numbers occurring in each postcode (r=.86; significant at p<.001). Hence, suburbs or postcodes documenting high total numbers of vegetation fires also typically recorded high numbers of vegetation fires started by children. Due to the low frequencies of child fires, such trends need to be treated with caution. However, they may provide a working basis for tackling the issue of child fires in some areas of Tasmania.

The greatest number of fires started by abandoned or discarded materials (**smoking-related fires**) occurred in the Greater Hobart, North West, and Greater Launceston regions. These regions accounted for 22, 17 and 16 percent of documented smoking-related TFS-attended fires, respectively (Figure 14). Nevertheless, smoking-related fires accounted for the highest proportion of all fires within a region in the East Coast (10%), and to a lesser extent Northern, North West and Greater Launceston areas (approximately 5%; Figure 14). Smoking-related fires were responsible for less than two percent of fires in the Southern and Greater Hobart region. Based on results from other jurisdictions it is somewhat unusual that the highest proportion of smoking-related fires occurred in regional as opposed to metropolitan areas.

Postcode

All vegetation fires: There is a large degree of heterogeneity of fire incidence at a postcode level. One postcode in the Greater Hobart region recorded in excess of 1,000 vegetation fires (all causes) in the five years, accounting for 28 percent of all vegetation fires in the Greater Hobart region and 13 percent of all TFS-attended vegetation fires in Tasmania over the five-year period (Table 2; Figure 15). A further four postcodes, two each in the Greater Hobart and Greater Launceston regions recorded 200 to 499 fires during the same period. Postcodes recording 200 to 499 fires accounted for two-thirds of fires in the Greater Launceston, and just over one-quarter of fires in the Greater Hobart region (Table 2; Figure 15). The five postcodes recording in excess of 500 fires in five years accounted for 38 percent of all vegetation fires the TFS documented.

A further eight postcodes recorded 200 to 499 fires – Greater Hobart (3), Greater Launceston (1), North West (3), Southern (1) – and 18 postcodes recorded 100 to 199 postcodes in five years. The 31 postcodes having 100 or more fires accounted for 38 and 77 percent of all TFS-attended fires for the five-year period (Figure 15).

Table 2: Number of postcodes within specific fire frequency ranges for 1999–2000 to 2003–04 for each region

	Tasmania		G. Hobart		G. Launceston		North West		Northern		Southern		East Coast		West Coast	
Suburbs	No. suburbs	% fires	No. suburbs	% fires	No. suburbs	% fires	No. suburbs	% fires	No. suburbs	% fires	No. suburbs	% fires	No. suburbs	% fires	No. suburbs	% fires
All vegetation fires																
>1000	1	13.3	1	28.1												
500–999	4	24.5	2	27.4	2	67.6										
200–499	8	19.2	3	18.0	1	10.7	3	46.5			1	25.9				
100–199	18	19.5	6	13.6	1	5.5	5	36.7	2	26.5	3	35.0	1	54.4		
50–99	18	11.1	4	5.9	3	10.3	1	4.3	8	44.6	1	8.3	1	34.1		
<50	64	12.3	16	7.0	4	6.0	4	12.4	14	28.9	21	30.9	1	11.5	4	100
Deliberate vegetation fires																
>500	2	36.2	2	59.7												
200–499	3	24.4	1	9.0	2	83.4										
100–199	6	16.4	3	14.2	1	11.8	2	56.2								
50–99	3	4.9	2	5.6							1	28.3				
25–49	12	8.6	5	6.0	1	3.9	3	22.5			3	36.7				
<25	70	9.4	17	5.5	5	0.9	8	21.3	15	100	18	35.1	3	100	4	100

Deliberate vegetation fires were more highly concentrated within specific locations than total fire frequencies. This is illustrated by the statistics that show:

- Two postcodes in Tasmanian recorded in excess of 500 deliberate fires in five years. Both were located in the Greater Hobart region. These two postcodes accounted for 60 and 36 percent of all deliberate vegetation fires the TFS attended in the Greater Hobart region and in Tasmania respectively (Table 2; Figure 16).
- Two postcodes in the Greater Launceston region recorded more than 200 deliberate fires in five years. These two postcodes accounted for 83 percent of fires in the Greater Launceston region.
- Two postcodes in the North West region recorded more than 100 deliberate fires in five years. These postcodes accounted for 60 percent of all deliberate fires in the North West region.
- Overall, the 11 postcodes in Tasmania with more than 20 deliberate fires per year (100 deliberate fires in five years) were responsible for more than three-quarters of all deliberate fires the TFS attended in Tasmania.

Broadly, there was a tendency for the percentage of deliberate vegetation fires to increase as the number of vegetation fires within individual postcodes increased (Figure 17). Commonly, between 50 and 80 percent of fires were deliberate in postcodes recording in excess of 200 deliberate vegetation fires in five years. The few suburbs that documented high numbers and high proportions of deliberate fires markedly affected the statistics for deliberate fires observed in those regions. For example, if postcodes with greater than 500 fires are excluded, the percentage of deliberate fires in the Greater Hobart region drops from 48 to 32 percent.

Population analysis

The general tendency for the highest numbers of vegetation fires to occur in areas where there are the greatest numbers of people breaks down under detailed examination. The analysis in this section examines the relationship between fire incidence and population.

All vegetation fires: Both regional and urban postcodes experienced a broad range of fires on a per-person-per-year basis (Figure 18). Collectively, individual postcodes in Tasmania (TFS fires only) recorded seven to 380 vegetation fires per 10,000 people per year. Overall, the numbers of fires per 10,000 people per year decreased with increasing population size, principally because of the highly diverse nature of the rates calculated for small communities. That smaller communities (postcodes) commonly experienced a higher number of fires than larger communities on a per-person basis is not surprising as:

- The lowest rate of fires per person is defined by a single fire event within a postcode in five years. A single fire in a small community will necessarily lead to higher rates than in a larger community. A longer observation period is required in smaller communities to yield adequate sampling statistics.
- The causes of vegetation fires are not mutually exclusive; one fire started by a cigarette does not prevent another from starting naturally, or by accidental causes or arson. Again this most strongly affects small communities.
- Greater expanses of vegetation and the higher probability that residents will undertake activities that may ignite fires (e.g. land maintenance activities like slashing, welding, back burning, forestry, etc.), means multiple fire origins will most strongly affect postcodes in regional areas. This might explain the comparatively high rates of fires per person within the Northern region.

Nevertheless, not all small communities were characterised by higher rates of fires per person and conversely not all large communities are characterised by low rates of fires per person. The three postcodes in the Greater Hobart region that recorded in excess of 500 fires in five years had rates of 100 to 400 fires per 10,000 people per year, well above that observed in other densely populated urban areas in Tasmania. This was not evident for the two Greater Launceston postcodes that recorded more than 500 vegetation fires in five years.

Deliberate fires: A single deliberate fire within a postcode in five years determined the lowest natural, non-zero, limit for deliberate vegetation fires per person per year (Line A, Figure 19). Hence, the minimum rate of deliberate fires per 10,000 people per year decreased with increasing population size. Nevertheless, this decrease only occurred up to a point, beyond which the rate of deliberate vegetation fires per 10,000 people increased with increasing postcode population. For Tasmania this critical point occurred for a postcode population of approximately 5,000 people. The location of this point is determined not only by the length of the observation period but also by the general level of deliberate firesetting within the region or jurisdiction. The increase in the minimum rate of deliberate fires per 10,000 people, beyond the critical point, is likely to be a function of the natural growth constant. That is, as postcodes grow beyond 5,000 people there is a predictable lower limit to the number of deliberate fires that are likely to occur each year.

In contrast to the trend observed for vegetation fires generally, the maximum rate of deliberate fires per 10,000 people typically remained stable across postcodes with highly diverse populations. The notable exceptions were two postcodes within the Greater Hobart region and to a lesser extent two postcodes within the Greater Launceston region. That the two postcodes within the Greater Launceston region record higher rates of deliberate vegetation fires but not exceptionally high rates of vegetation fires generally (all causes) on a per person basis is indicative that a high proportion of all fires in those postcodes were deliberate in origin. Postcodes that experienced greater than 100 fires per year were rare, and occurred exclusively within the Greater Hobart and Greater Launceston regions. Both postcodes from the Greater Hobart region had elevated numbers of vegetation fires in general.

The lines included in Figure 19 provide a guide to the relationship between rates on a per 10,000 person basis and the actual number of deliberate vegetation fires that occurred in different sized communities (postcodes). For example, a rate of 0.001 fires per person translates as one fire every 10 years, one fire per year and 10 fires per year in communities of 100, 1,000 and 10,000 people respectively. The Greater Hobart, Greater Launceston and North West regions have the greatest number of postcodes with populations exceeding 5,000 (i.e. most populated regions) and hence account for the majority of postcodes that experienced greater than five deliberate lightings per year. The implication is that the level at which deliberate fires is considered problematic may need to be adjusted to take into account differences in population densities.

Although within the range observed elsewhere, the rate of deliberate fires per 10,000 people per year was consistently high for postcodes in the Southern region, with higher rates observed across both small and large (exceeding 10,000 people) populations. That deliberate firesetting is potentially an issue in this region becomes more apparent if one takes into account that the cause of 37 percent of fires in this region was unknown.

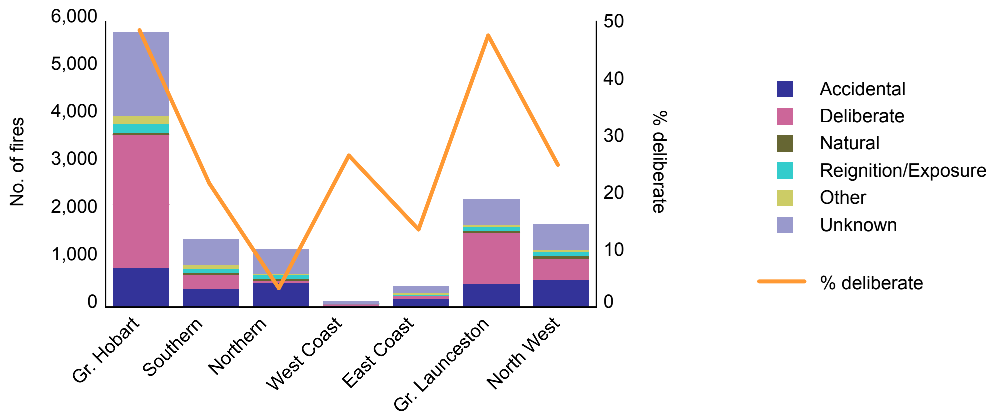
As would be expected, the rate of fires resulting from **inadequate fire control** per 10,000 people per year was lowest in the Greater Hobart and Greater Launceston postcodes (Figure 20). Nevertheless, two Greater Hobart postcodes experienced an average of more than five fires per year resulting from this cause. The highest rates of fires resulting from inadequate fire control per 10,000 people per year occurred in the Northern and North West regions (Figure 20).

Overall, the rate of **smoking-related fires** per 10,000 people per year decreased with increasing population size (Figure 21). This is not unexpected given that smoking-related fires accounted for the highest proportion of all fire causes in many regional areas. Three postcodes in Tasmania experienced an average of more than five smoking-related fires per year; one each from the East Coast, North West and Greater Launceston regions. More than half the postcodes within Greater Hobart and Greater Launceston experienced between one and five smoking-related fires per year.

Figure 11: Tourism regions of Tasmania

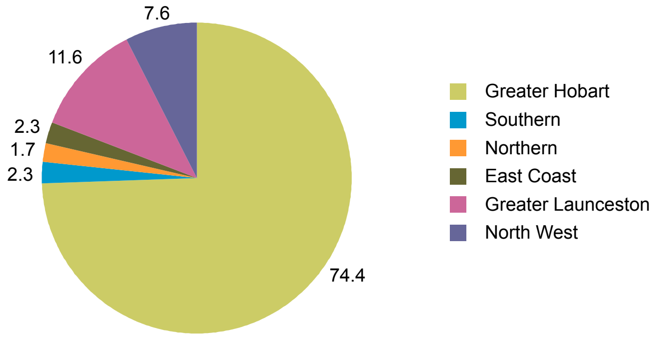
Source: ABS 2005b

Figure 12: Cause of fires in each region



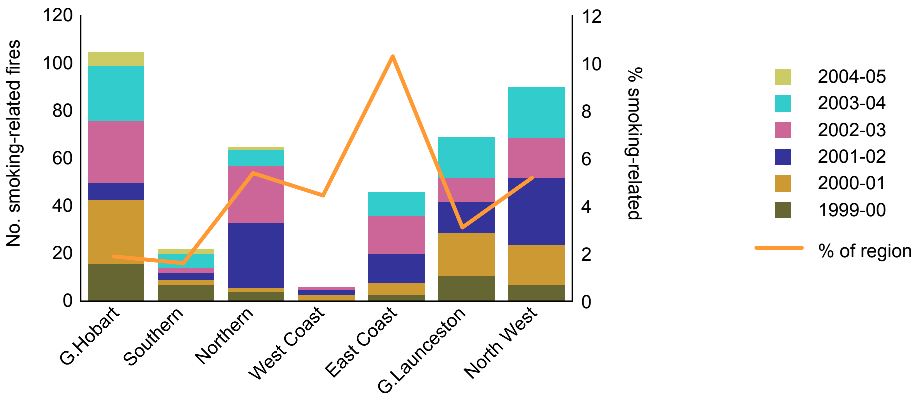
Source: TFS 1999–2000 to 2003–04 [computer file]

Figure 13: Non-deliberate child fires by region (percent)



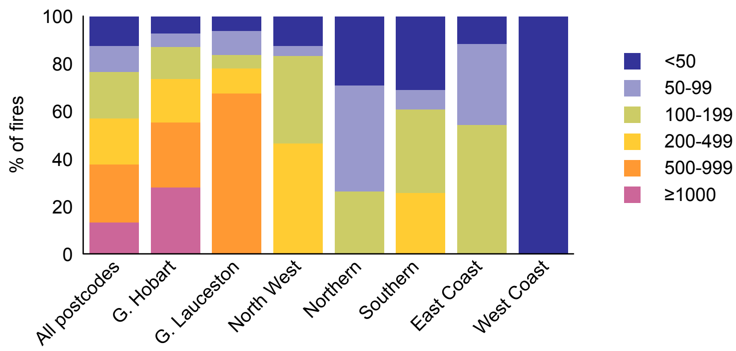
Source: TFS 1999–2000 to November 2004 [computer file]

Figure 14: Smoking-related fires by region



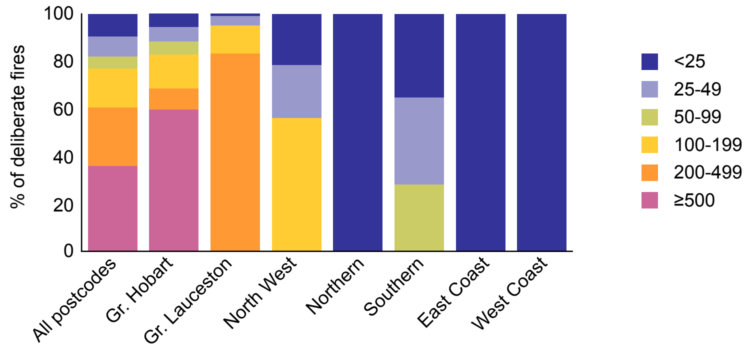
Source: TFS 1999–2000 to November 2004 [computer file]

Figure 15: Fire frequency distribution (all causes) for postcodes within each region (percent)



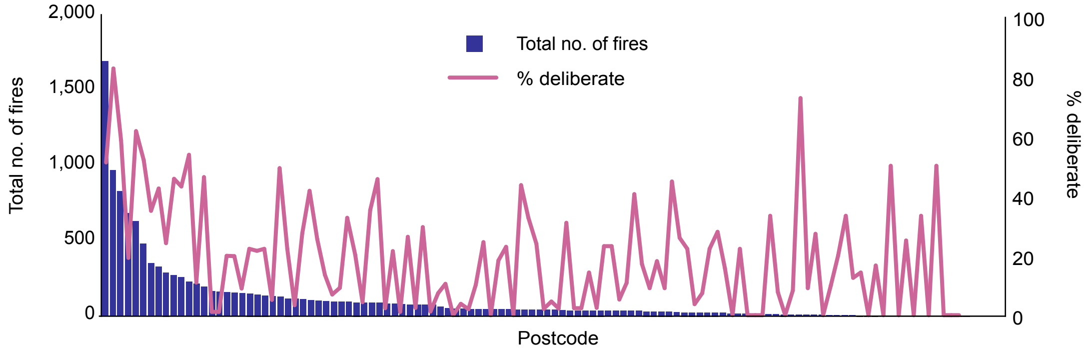
Source: TFS 1999–2000 to 2003–04 [computer file]

Figure 16: Fire frequency distribution (deliberate causes) for postcodes within each region (percent)



Source: TFS 1999–2000 to 2003–04 [computer file]

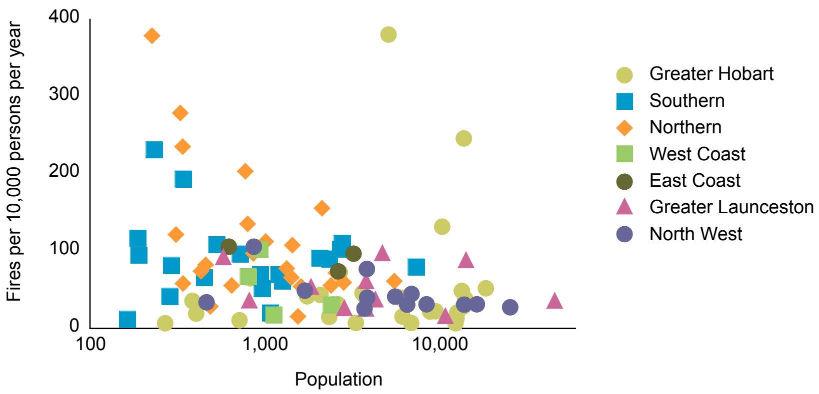
Figure 17: Number of fires (all causes) and percentage deliberate fires by postcode[a]



a: postcodes are not identified and are arranged in order of decreasing numbers of fires

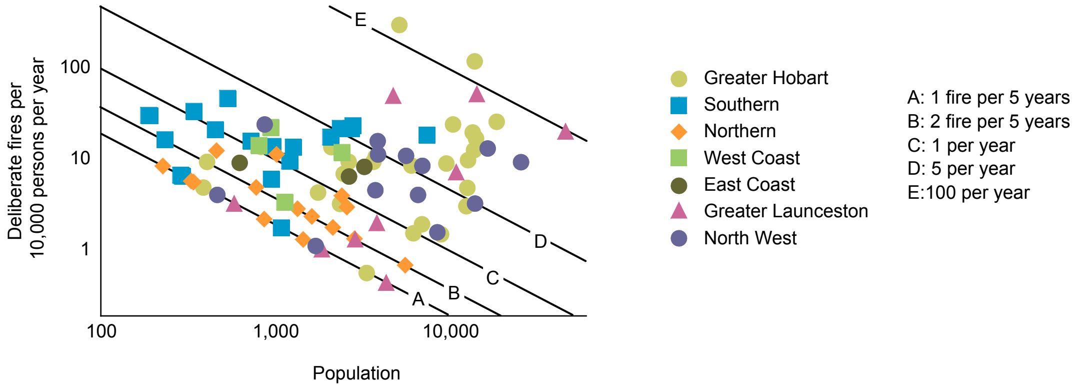
Source: TFS 1999–2000 to 2003–04 [computer file]

Figure 18: Fire densities by population for each region (number)



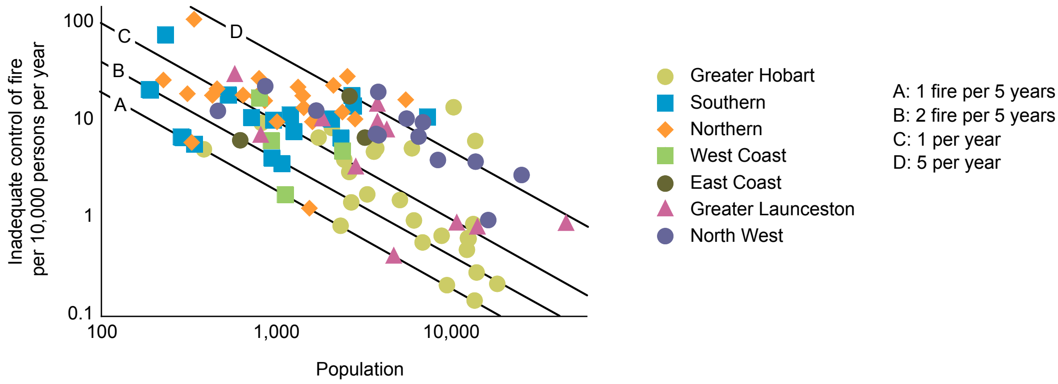
Source: TFS 1999–2000 to 2003–04 [computer file]; ABS 2004. Population by post office area, 2001 [computer file]

Figure 19: Deliberate fire densities by population for each region (number)



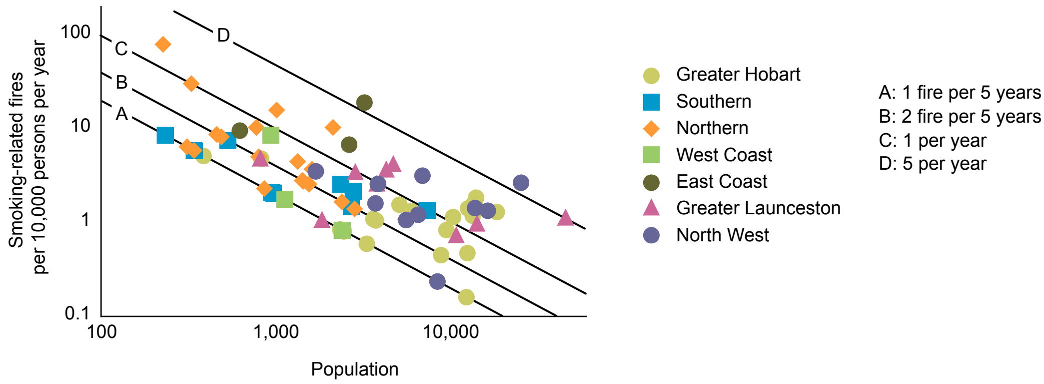
Source: TFS 1999–2000 to 2003–04 [computer file]; ABS 2004. Population by post office area, 2001 [computer file]

Figure 20: Density of fires resulting from inadequate control of a fire by population for each region (number)



Source: TFS 1999–2000 to 2003–04 [computer file]; ABS 2004. Population by post office area, 2001 [computer file]

Figure 21: Density of fires resulting from discarded/abandoned materials by population for each region (number)



Source: TFS 1999–2000 to 2003–04 [computer file]; ABS 2004. Population by post office area, 2001 [computer file]

Timing

The timing of fires is examined by week of the year and day of the week.

Week of the year

The majority of vegetation fires, irrespective of cause, occurred between November and mid April (Figure 22). The distribution of fires varied markedly between years (Figure 23) depending on the amount and timing of spring/summer/autumn rainfall (Figure 24), consequently:

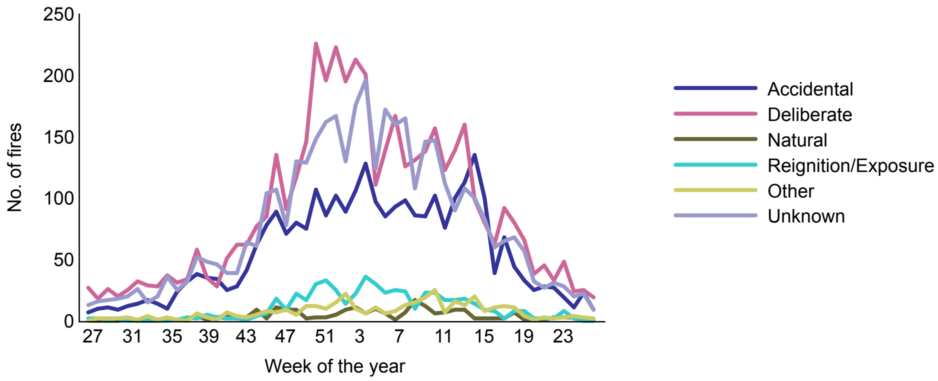
- Comparatively low rainfall in 1999–2000 resulted in elevated fire numbers from December to mid April.
- The year of 2000–01 was similar to 1999–2000, except that in March 2001 rains shortened the bushfire danger season.
- Higher spring and summer rainfall in 2001–02 resulted in lower total vegetation fire numbers during November–January. Fire numbers subsequently increased in February and peaked in late March to early April, coincident with the lower rainfall observed during that period.
- In 2002–03 fire frequencies increased rapidly in late October and peaked during December and January, coincident with an exceptionally dry period that lasted from November to February.
- The 2003–04 bushfire season was marked by three separate peaks in fire activity. The season started early with a massive increase in fire frequencies during weeks 45 and 46 and exceptionally low October–November rainfall. The timing of this peak coincided with the early start observed for 2002–03. Comparatively low fire frequencies occurred in December owing to increased rainfall in that month. The second spike in fire frequencies began in late December but principally occurred in January, despite January recording comparatively high average rainfall figures overall. The third, smaller, peak occur in late March–early April following low February–March rainfall.

Overall, there was strong correlation between timing of non-deliberate and deliberate fires in a given season; that is, increases and decreases in deliberate and non-deliberate fires typically occurred simultaneous and, to a similar degree, commonly. The most notable discrepancy occurred for fires in weeks 50 to 6 (Figure 22), coincident with Christmas school holidays, and the first two weeks of the school term. During this period the number of deliberate fires noticeably outweighed the number of non-deliberate fires. This was not observed in all years, but was most evident during 2002–03 (Figure 25) and, to a lesser extent, 2003–04 (Figure 26) and 2000–01. These were all years in which more adverse bushfire weather conditions coincided with the Christmas school holidays.

In December 2002, the number of deliberate fires was more than double that observed for non-deliberate fires during the same period. Such a high rate of deliberate fires during an adverse bushfire season is obviously of concern. More promising was that the numbers of deliberate fires decreased rapidly in January, despite the likely increased media coverage of the devastating fires in northeast Victoria, southeast New South Wales and the Australian Capital Territory. It is unclear what precipitated this turnaround, whether it reflected an awareness of the severity of the bushfire danger, public awareness campaigns relating to inherent bushfire danger, increased police involvement, or some other cause. An alternative explanation, at least for one of the postcodes, is that fire frequencies were affected by the presence of a large fire in the neighbouring area (Broadmarsh).

Accidental fires lit by 6 to 12 year olds and 13 to 16 year olds spiked during weeks 3 and 4, coincident with the end of the Christmas school holidays (Figure 27). This subtle increase in fire numbers was evident for all five years surveyed, although the overall increase was small. In two of the five years there was an additional spike in the number of accidental fires lit by 13 to 16 year olds in weeks 47 and 48 (late November–early December). This may be coincident with the end of term for some children within this age group.

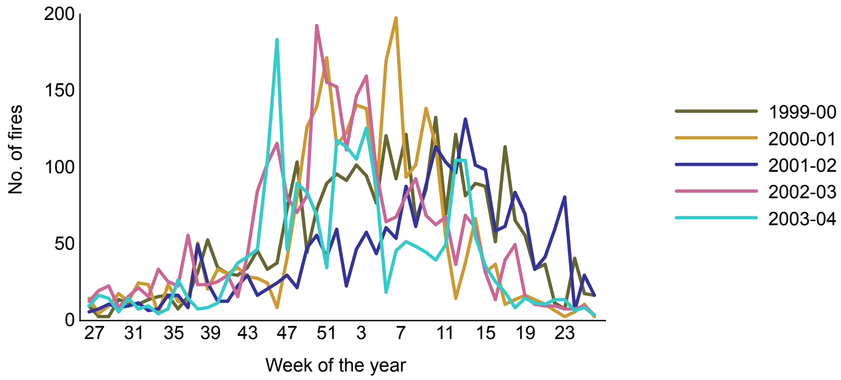
Figure 22: Week of the year[a], by cause (number)



a: week 1 refers to the first calendar week of the year

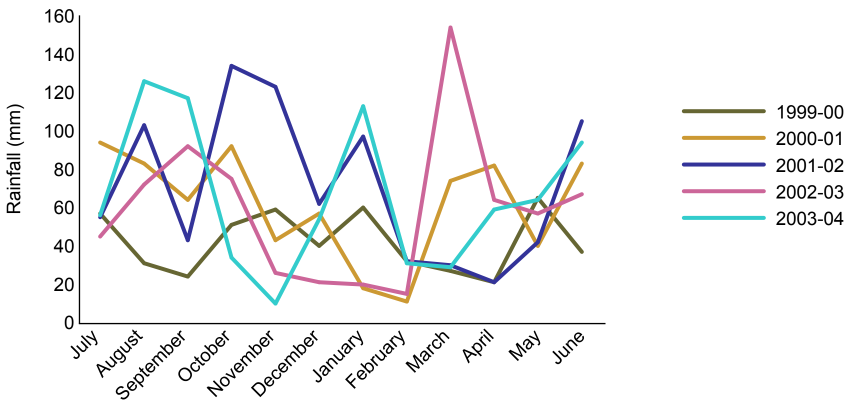
Source: TFS 1999–2000 to 2003–04 [computer file]

Figure 23: Week of the year each year (number)



Source: TFS 1999–2000 to 2003–04 [computer file]

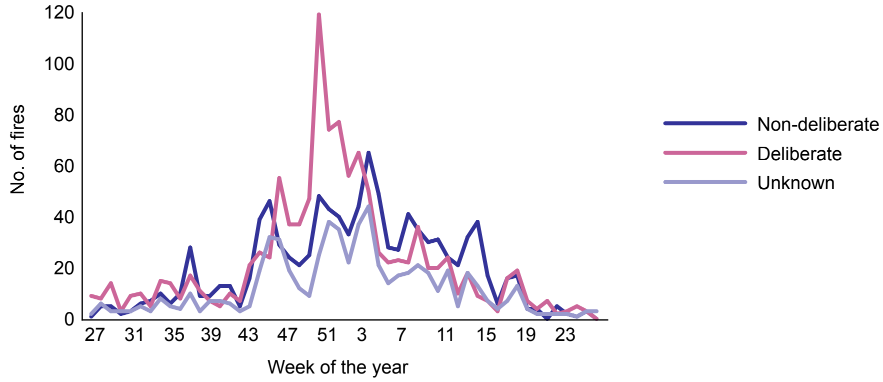
Figure 24: Southeast Tasmania – district rainfall average[a], 1999–2000 to 2003–04 (number)



a: monthly gridded rainfall data

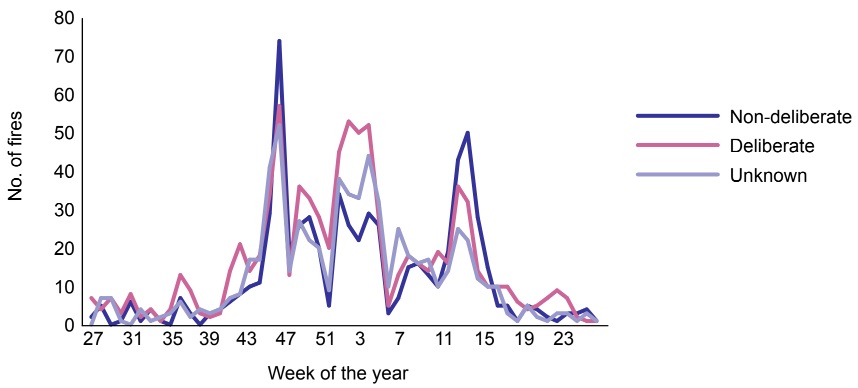
Source: Australian Bureau of Meteorology [computer file]

Figure 25: Week of the year, by cause, 2002–03 (number)



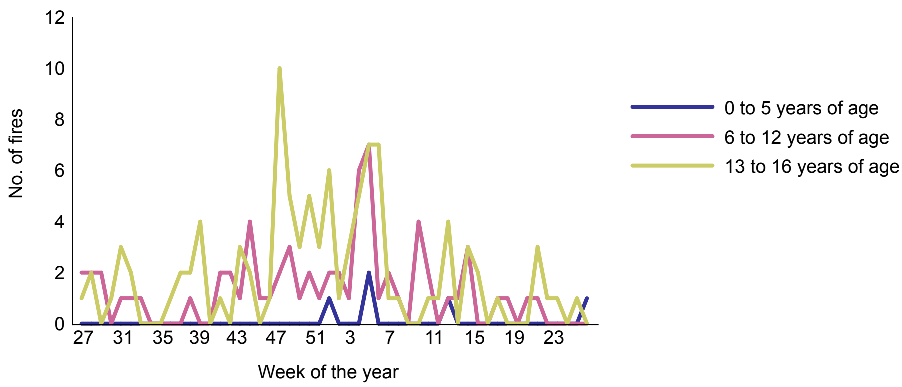
Source: TFS 2002–03 [computer file]

Figure 26: Week of the year, by cause, 2003–04 (number)



Source: TFS 2003–04 [computer file]

Figure 27: Non-deliberate child fires, by week of the year and child's age (number)



Source: TFS 1999–2000 to November 2004 [computer file]

Day of the week

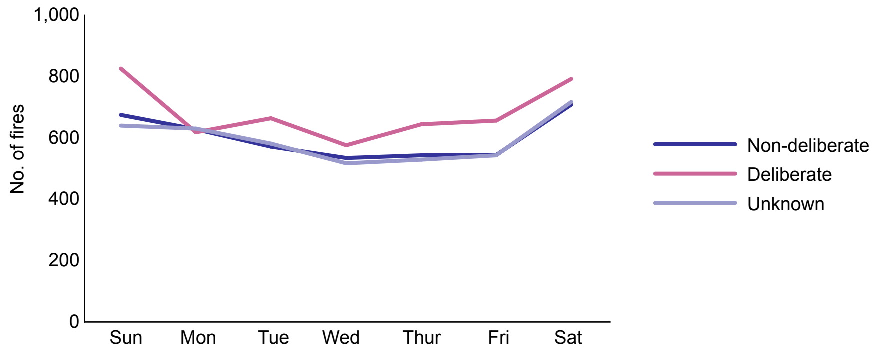
Overall, 26 percent more fires occurred on Saturday and 22 percent more fires occurred on Sunday relative to the weekday average. The numbers of non-deliberate and unknown causes decreased throughout the week before climbing sharply on Saturday, whereas the numbers of deliberate fires were consistently higher (25 to 31 percent higher) on both Saturday and Sunday than all weekdays (Figure 28). Overall, the number of deliberate fires that occurred on weekdays was comparatively uniform.

The propensity for weekend fires varied on both regional and local scales. In Greater Hobart, vegetation fires of all causes were 28 percent higher on Sunday and 22 percent higher on Sunday, relative to the weekday average. In Greater Launceston vegetation fires (all causes) were 27 percent more likely on Saturday and 40 percent more likely on Sunday (Figure 29). Higher numbers of Saturday fires, relative to the weekday average, were observed across all regions, whereas higher average numbers of vegetation fires on Sunday occurred only in the North West and Northern regions.

The trends presented for any one region were necessarily an aggregation of many different trends that occurred on local scales. The postcodes recording the highest number of fires in the Greater Hobart region did not generally have a strong weekend bias; fires could occur on any day of the week (Figure 30). In contrast, some suburbs had decidedly more fires on weekends than during the week whereas others were characterised by higher numbers of fires during the middle of the week (Figure 31). Clearly, the timing of fires needs to be examined in detail on a local scale, to identify the specific causes of increased fire numbers in each area and to enable the most appropriate fire reduction strategies to be implemented.

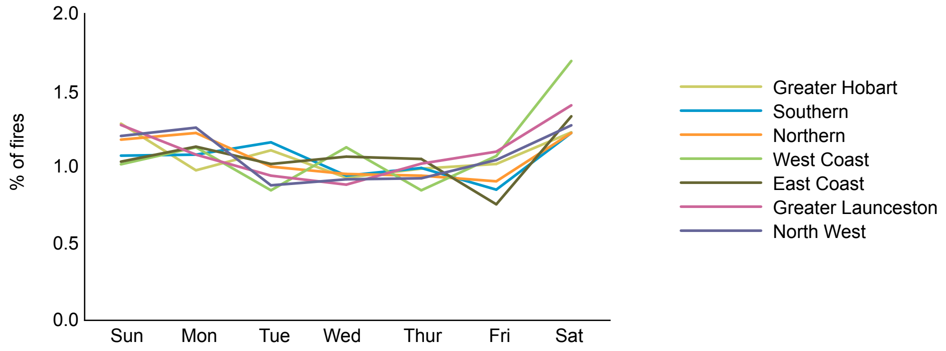
Accidental fires lit by children aged 6 to 12 were most commonly documented on Friday and Saturday, as compared to the middle of the week. In contrast, the greatest frequency for 13 to 16 year olds occurred on Sunday and Monday (Figure 32). These trends need to be treated with caution given the low frequency of child fires in general, but may be relevant to addressing the issue of child fires in some areas of Tasmania.

Figure 28: Day of the week, by cause (number)



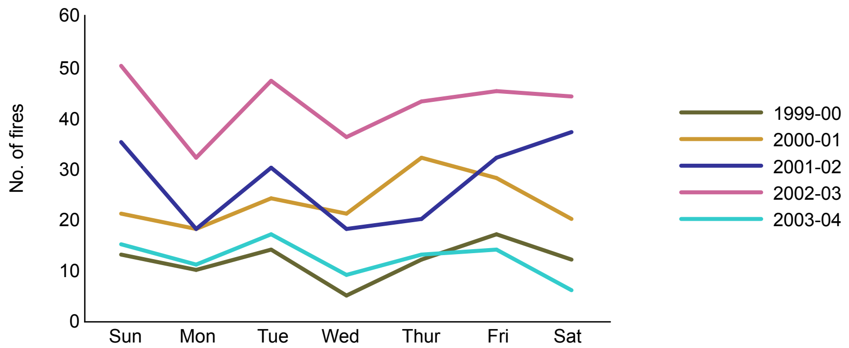
Source: TFS 1999–2000 to November 2004 [computer file]

Figure 29: Day of the week, by region (number)



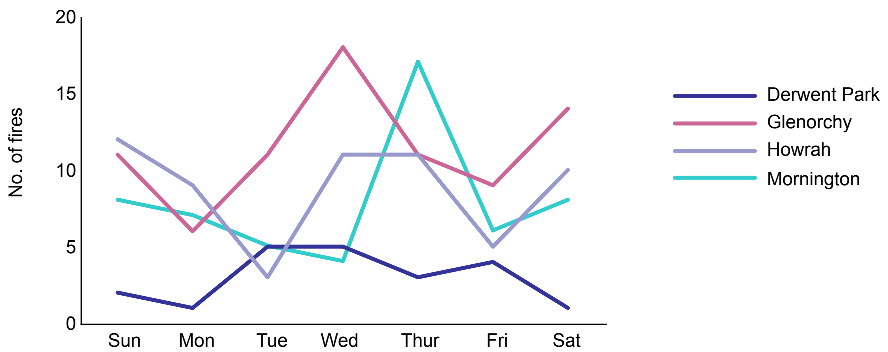
Source: TFS 1999–2000 to November 2004 [computer file]

Figure 30: Day of the week for one neighbourhood in the Greater Hobart region that experienced high numbers of fires, by year (number)



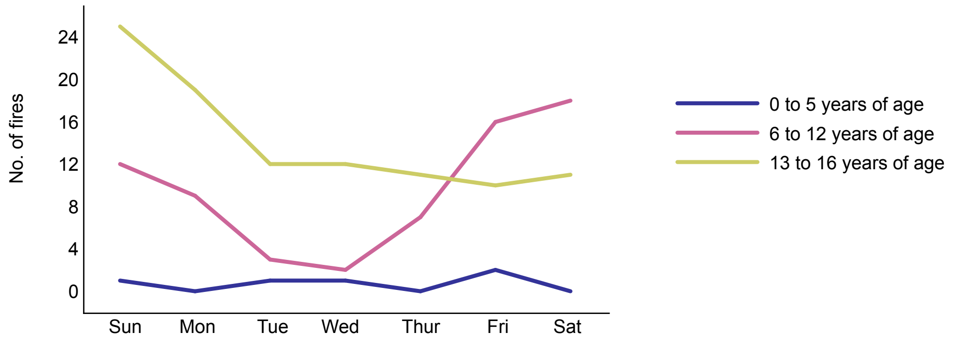
Source: TFS 1999–2000 to 2003–04 [computer file]

Figure 31: Day of the week for selected Hobart suburbs (number)



Source: TFS 1999–2000 to November 2004 [computer file]

Figure 32: Non-deliberate child fires, by day of the week and age group (number)



Source: TFS 1999–2000 to November 2004 [computer file]

Area burned

The size of most TFS-attended vegetation fires was small, with the frequency of fires decreasing with increasing area burned. Nevertheless, the characteristic hump for fires in the 10 to 50 ha range remained (Figure 33). Although, this general trend occurred, irrespective of cause, subtle differences were evident in size distribution of vegetation fires of different causes.

Overall, natural causes accounted for an increasing proportion of fires with increasing fire size (Figure 34), and fires started by lightning were the only known cause of fires greater than 5,000 ha in Tasmania between 1999–2000 and 2003–04. In contrast, there was a tendency for deliberate fires to account for a small proportion of fires within an area burned category as the size of the area burned increased (Figure 34). Although these results are consistent with the trend observed in most other jurisdictions, caution should be exercised when interpreting the results, as the proportion of unknown fires also increased with increasing fire size. That is, there was a greater probability that the cause of larger fires was unknown, compared to small fires.

Collectively, around 190,000 ha were burned in TFS-attended fires between July 1999 and November 2004. This does not represent the total area burned in Tasmania during the observation period, as the TFS database does not include all Forestry Tasmania or Parks and Wildlife Service fires.

The area burned in any one year was highly variable, ranging from 5,000 to 15,000 ha from 1999–2000 to 2001–02, up to 50,000 to 100,000 ha in 2002–03 and 2003–04 (Figure 35). Large fire events dominated total area burned statistics. More than half the 56,480 ha burned in 2002–03 was as a result of two fires; a fire started by lightning burned 17,500 ha on Flinders Island (Ellis, Kanowski & Whelan, 2004) and a fire of unknown origin burned 14,300 ha in the Southern region. In 2003–04, a large fire of unknown origin and another attributed to lightning burned approximately 70,000 and 8,900 ha, respectively in mid November (week 46) in North West Tasmania. This week corresponded to a particularly adverse week when a high number of vegetation fires occurred across many parts of the state (Figure 24).

Although 36 percent of vegetation fires the TFS attended between July 1999 and November 2004 were deliberate, these fires accounted for only 6.6 percent (12,756 ha) of the total area burned (Figure 36). The greatest total area burned by deliberate fires occurred in 2003–04 (5,332 ha) and 2002–03 (3,790 ha; Figure 35). However, deliberate fires only accounted for five to seven percent of the total area burned in those two years owing to the large areas burned by other fire causes. Deliberate fires tended to burn the greatest proportion (up to 19%) of land in years characterised by low total areas burned (Figure 35); that is, less adverse fire seasons. This is not to understate the potential danger posed by deliberate fires. There were two instances where deliberate fires burned greater than 1,000 ha, the largest having burned

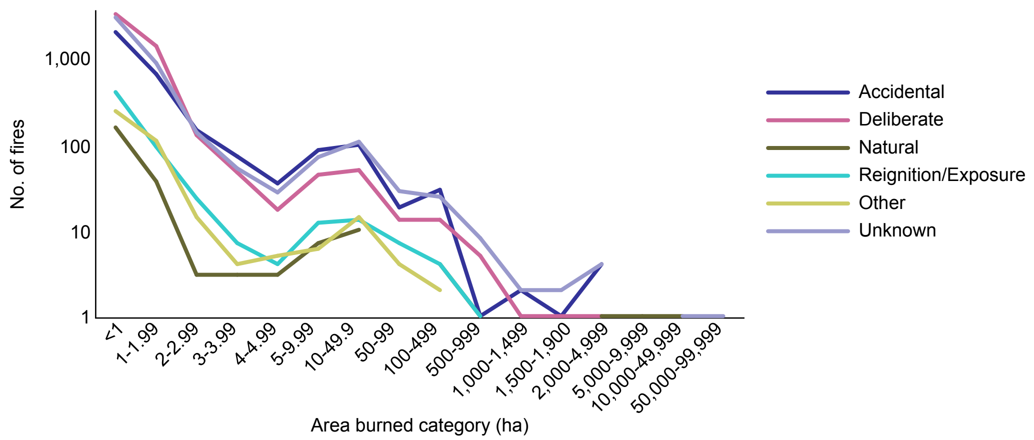
2,100 ha. Moreover, almost one-third of fires in the 500–1,000 ha range were incendiary in origin (n=5); 82 deliberate fires burned greater than 10 ha.

It is not surprising given their size distribution that natural fires and fires started by lightning in particular, accounted for the largest area burned by a known cause (17% of the total area burned; Figure 36). Accidental fires accounted for a further 13 percent of the total area burned. The cause of the many large fires in Tasmania was unknown, with unknown causes accounting for almost two-thirds of the total area burned.

The majority of the total area burned in Tasmania (at least in TFS-attended fires) occurred in the North West (44%), Southern (25%) and Northern (21%) regions. Vegetation fires in the Greater Hobart and Greater Launceston regions accounted for just three and four percent of the total area burned, respectively (Figure 37).

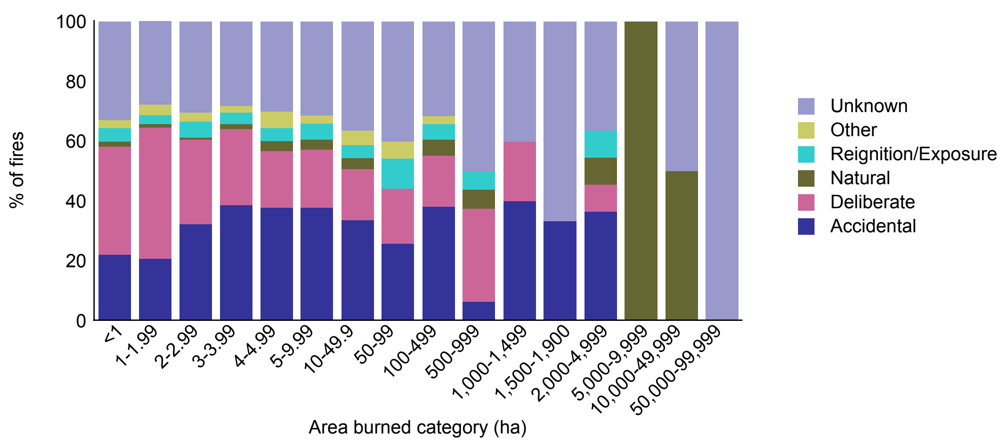
In the North West, Southern and to a lesser extent the East Coast regions fires of unknown cause were a major contributor, whereas in the Greater Hobart and West Coast regions deliberate fires made larger contributions. Natural conditions accounted for a high proportion of the total area burned in both the Northern and Greater Launceston regions. Proportionally, accidental factors were most significant in the East Coast and Greater Hobart regions, but did not feature, to any known extent, in the North West (Figure 38).

Figure 33: Area burned category, by cause (number)



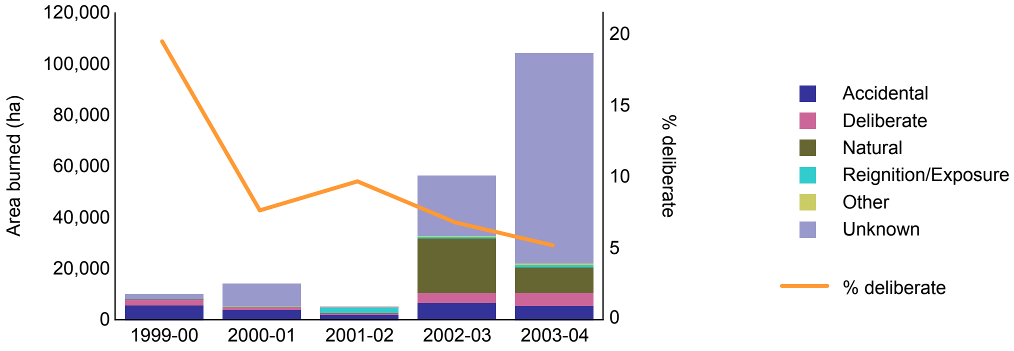
Source: TFS 1999–2000 to November 2004 [computer file]

Figure 34: Area burned category, by cause (percent)



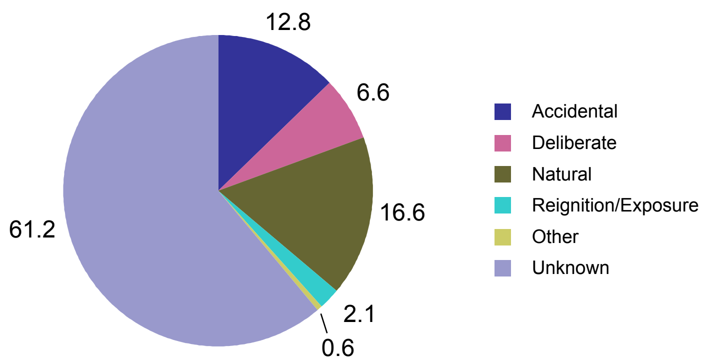
Source: TFS 1999–2000 to November 2004 [computer file]

Figure 35: Area burned, by cause each year



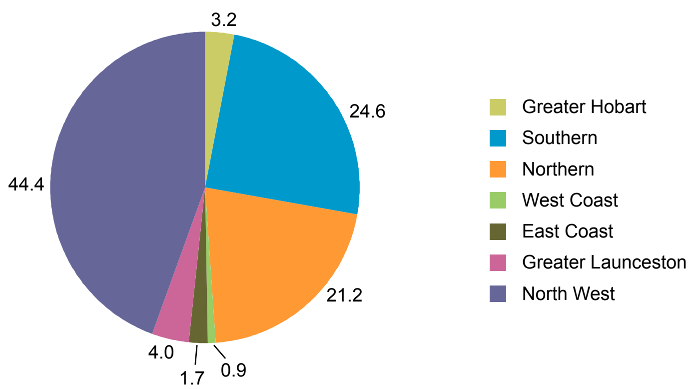
Source: TFS 1999–2000 to 2003–04 [computer file]

Figure 36: Area burned, by cause (percent)



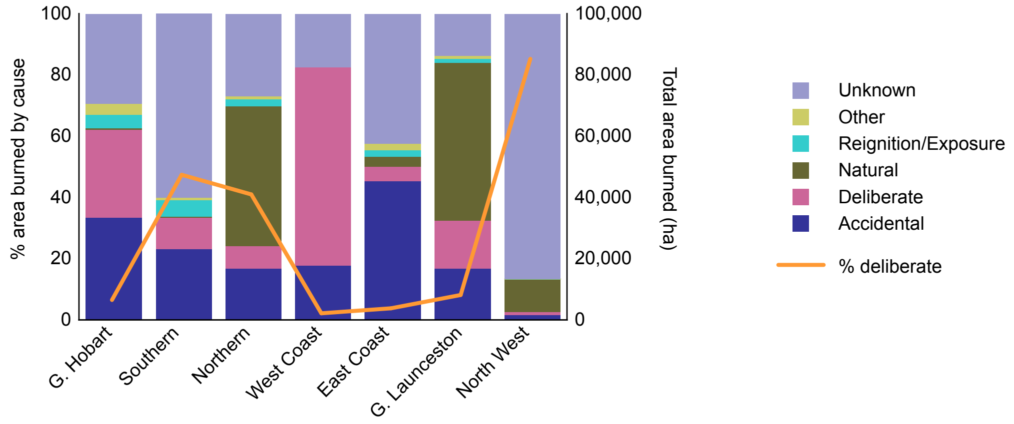
Source: TFS 1999–2000 to November 2004 [computer file]

Figure 37: Area burned, by region (percent)



Source: TFS 1999–2000 to November 2004 [computer file]

Figure 38: Area burned in each region, by cause



Source: TFS 1999–2000 to 2003–04 [computer file]

Vegetation burned

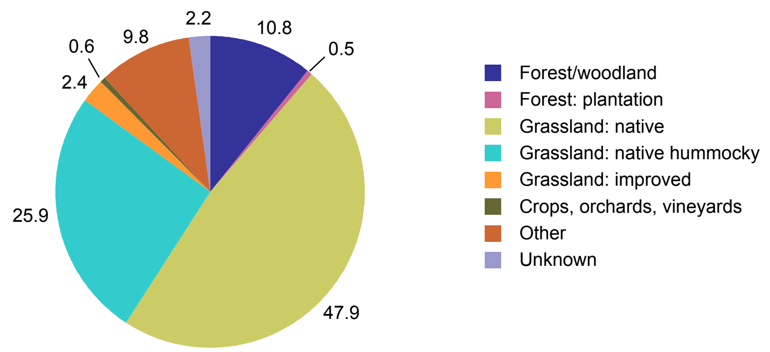
The majority of fires the TFS attended between 1999–2000 and November 2004 were grass fires. Almost three-quarters of fires attended occurred in native grasslands (Figure 39), with one-third of those fires being in hummocky native grassland. Only 11 percent of fires occurred in forest or woodland; less than one percent was in forestry plantations; 10 percent occurred in other vegetation types.

Overall, the proportion of fires attributed to each cause varied across vegetation types (Figure 40). Subtle variations included a higher proportion of deliberate fires and a lower proportion of accidental fires in native hummocky grasslands and lower proportions of deliberate fires, but higher rates of accidental fires in forest plantations.

The size distribution of fires within each vegetation type paralleled that observed for fires generally, with fire frequency for individual vegetation types decreasing with increasing size (Figure 41). Although this general pattern was observed across most vegetation types some difference in size distribution were noted. For example, fires in hummocky native grasslands tended to account for a decreasing proportion of fires with increasing fire size, whereas fires in forest or woodlands accounted for a higher proportion as fire size increased. However, no woodland or forest fire exceeded 5,000 ha. All large vegetation fires greater than 5,000 ha occurred in native grassland.

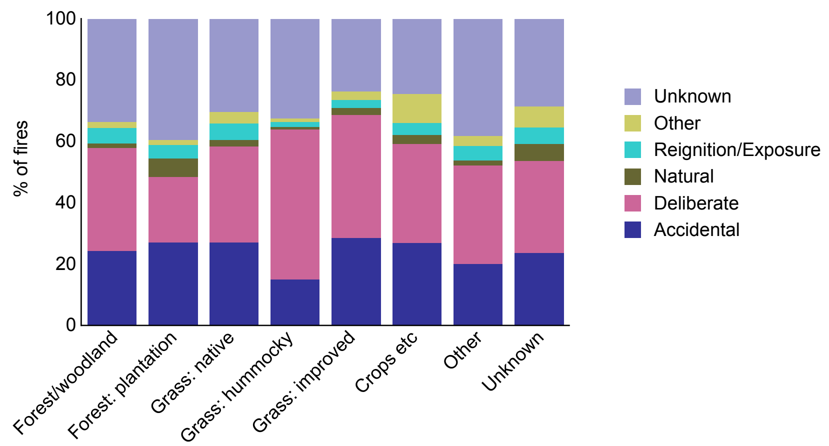
The size distribution for fires in hummocky native grasslands is more readily understood if the regional distribution of fires is examined. Namely, more than 60 percent of fires in hummocky native grasslands occurred in the Greater Hobart region, where fire size tended to be small. The low incidence of deliberate fires in forest plantations is understandable in light of the fact that few plantations are located near the major urban centres of Hobart and Launceston (Figure 43).

Figure 39: Vegetation type (percent)



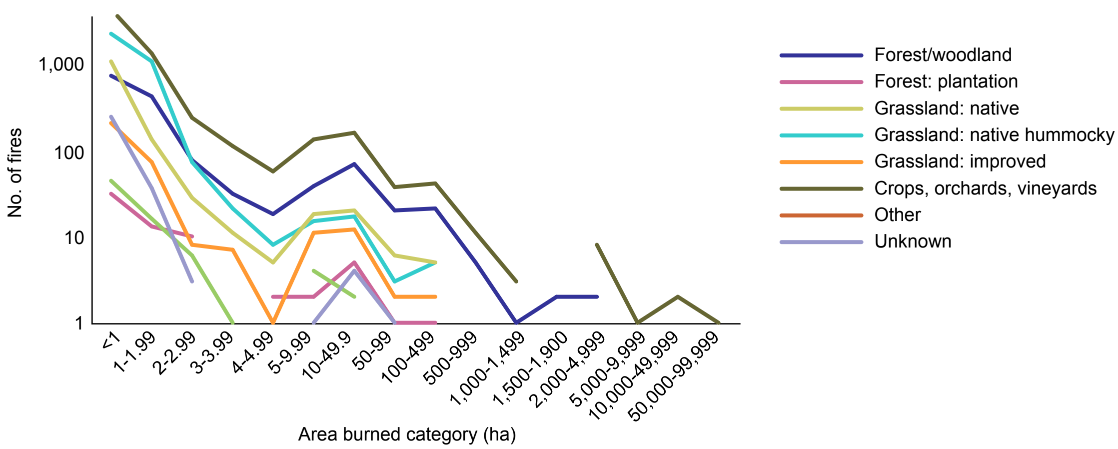
Source: TFS 1999–2000 to November 2004 [computer file]

Figure 40: Vegetation type, by cause (percent)



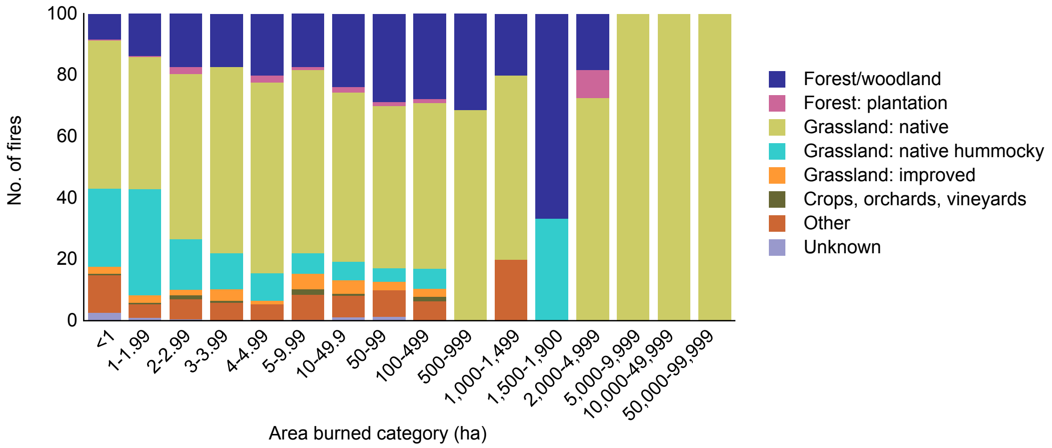
Source: TFS 1999–2000 to November 2004 [computer file]

Figure 41: Area burnt category, by vegetation type (number)



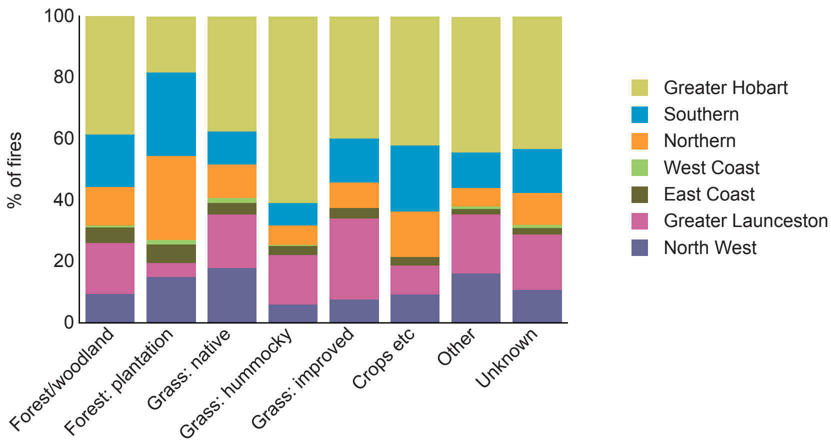
Source: TFS 1999–2000 to November 2004 [computer file]

Figure 42: Area burnt category, by vegetation type (percent)



Source: TFS 1999–2000 to November 2004 [computer file]

Figure 43: Vegetation type, by region (percent)



Source: TFS 1999–2000 to November 2004 [computer file]

Deliberate fires during peak fire danger

Periods of more adverse bushfire conditions occurred in both 2002–03 and 2003–04. Patterns of deliberate firesetting during these two periods are examined below.

In **2002–03** Australia experienced some of the driest conditions on record, and bushfires burned extensive areas of Victoria, New South Wales and the Australia Capital Territory during January 2003. Although not the worst on record, 2002–03 was clearly more severe than the previous couple of years in Tasmania. During week 50 of 2002 (mid December) there was a massive increase in the number of fires. Of the 192 fires that occurred in this week, 119 were deliberate, and of these 90 percent occurred in two postcodes in the Greater Hobart region, postcodes that overall recorded very high frequencies of fires. All deliberate fires in these postcodes were small, with no fires exceeding two ha in size. The largest deliberately fire, in week 50 of 2002–03, occurred in the Southern region.

The total number of fires remained high until week 3 of January 2003, coincident with the devastating bushfires in other states, when media coverage of bushfires was likely to have been high. However, by week 3, the number of deliberate fires was half that recorded in week 50 (before the intense media coverage of fires in Victoria, New South Wales and the Australian Capital Territory). Moreover, only half the fires that occurred in week 3 occurred in the two postcodes that recorded large numbers of fires in week 50 fires. The reason for the abatement of fires in those two postcodes is unclear, although in one of those areas, neighbouring fires, at Broadmarsh, may have played a part.

The vast majority of the area burned in **2003–04** occurred in a two-week period in November (weeks 45 and 46). As noted, extremely low rainfall occurred in October–November 2003, being even lower than that observed during the same period in 2002–03.

In week 45 the TFS attended 103 fires. The majority of these were small (71 percent were less than two hectares). The three largest were of unknown cause, and burned 450, 180 and 108 ha respectively. Approximately one-third of all fires during that week were deliberately lit, with two of the largest burning more than 50 ha each. Bushfire weather worsened in the following week, with the TFS recording 183 fires during week 46. There was clearly an increase in the number of deliberate fires during this week but the absolute percentage of deliberately lit fires did not increase. Although the majority of fires in week 46 were small (74 percent were less than two hectares), worsening bushfire weather led not only to increased numbers of fires for all causes, but also to increased fire size. Four fires burned more than 1,500 ha; of these, one was accidental, one was natural, and for two the cause was unknown. Deliberately lit fires also burned much greater areas, with the four largest burning 93, 400, 985 and 1,000 ha respectively.

There were interesting disparities between the 2003–04 and 2002–03 bushfire danger seasons. Deliberate fires during week 46 of 2003–04 occurred across 48 suburbs (compared to 26 during week 50 of 2002–03). All deliberate fires burning 10 ha or more occurred in regional Tasmania (four, Northern; one, West Coast; two, Southern). All four in the Northern region, including one that burned 1,000 ha, occurred near Scottsdale. Only about 30 percent of deliberate lightings during week 46 occurred in Greater Hobart region (as compared to the average of 59 percent during the previous year), and reduced numbers of fires occurred in the two postcodes that featured in 2002–03 deliberate lightings. In one of those postcodes, the lower number of fires may reflect prior burning off by local brigades to reduce fuel loads, and hence the ground available for subsequent burning. This strategy appears to have been successful given the reduced number of fires that occurred in that postcode during weeks 45 and 46 of the 2003–04 summer. Had this burning off not occurred, total vegetation fire frequencies during this adverse period might have been higher.

It also clear that there were more deliberate fires of larger size in regional Tasmania during 2003–04 than in 2002–03. Whether this represents worse bushfire weather or an increase in malicious/negligent ignitions in specific regional areas is unclear. However, this trend is somewhat problematic, not only because of the size and hence potential danger posed by the fires, but because of the greater affect that such events have on regional communities. Such large events place a heavy burden on the limited resources and personnel (many of whom may be volunteer) in these regions, resources that may already be stretched by concomitant firefighting duties in their or a neighbouring region. Hence, in taking into account the problematic nature of fire frequencies (deliberate and other causes) it is necessary to not only consider the total number of vegetation fires, but also the impacts they have on the resources available in that community.

Factors impacting on TFS fire frequencies

A number of factors may have had an impact on total vegetation fire frequencies both during and subsequent to this analysis. They include:

- The Broadmarsh fires may have affected total vegetation fire frequencies observed in one or more neighbouring postcodes during January 2003 (as discussed).

- Burn offs by brigades in specific areas traditionally associated with high fire frequencies, during 2003–04 reduced ground available for firesetting. This is reflected in the lower overall fire frequencies in those postcodes during 2003–04 (as discussed).
- In 2004–05 the TFS and the Tasmanian Police conducted a joint arson reduction campaign – Operation Hydra – in selected suburbs that had recorded a high incidence of deliberate fires. This campaign markedly reduced the incidence of fires in the targeted areas.

Summary

The most important points regarding the TFS analysis are summarised below:

- The TFS attended 13,083 vegetation fires from 1999–2000 until 23 November 2004; total fire numbers were broadly consistent across all fire years.
- Thirty-six percent of vegetation fires were deliberate (36.3% incendiary; 0.02% suspicious), with the cause of 32 percent of fires being unknown. Hence, deliberate actions accounted for 53 percent of known causes.
- Natural fires accounted for 1.7 percent of all TFS fires. Of these roughly only one-quarter were attributed directly to lightning.
- Non-deliberate fires lit by children accounted for 1.3 percent of vegetation fires the TFS attended. The number of non-deliberate fires increased with the age of the child. Three-quarters of these occurred in the Greater Hobart region. Peaks in non-deliberate child fires occurred at the beginning and end of the Christmas school holidays.
- Smoking-related materials comprised 3.1 percent (minimum value) of TFS-attended vegetation fires. A disproportionate amount of these occurred in regional areas.
- Almost two-thirds of all TFS-attended vegetation fires occurred in the two regions that incorporate the largest urban centres, namely, Hobart (44%) and Launceston (17%). These regions also had the highest proportion of deliberate fires (47 to 48 percent deliberate), and collectively accounted for 82 percent of deliberate fires in Tasmania.
- Deliberate fire occurrences were disproportionately concentrated in a small number of locations; the 11 postcodes in Tasmania that recorded 100 or more deliberate fires in five years accounted for three-quarters of all deliberate fires the TFS attended.
- Overall, a uniform maximum upper limit for deliberate fires in Tasmanian sits at 25 to 50 fires per 10,000 people, irrespective of postcode population. The only locations to exceed this level – two postcodes each in the Greater Hobart and Greater Launceston regions – recorded between 50 and 320 deliberate fires per 10,000 people per year.
- Broadly, there is a tendency for the proportion of deliberate fires to increase with increasing total numbers of vegetation fires, within individual suburbs.
- Vegetation fires principally occurred between November and mid April. However, the timing was highly subject to rainfall distribution, which varied markedly between seasons.
- Fluctuations in the number of deliberate fires strongly paralleled that observed for non-deliberate fires during the same season, although there is a greater propensity for deliberate fires to outweigh non-deliberate fires in those years where the bushfire season coincides with the Christmas school holidays.
- On average, deliberate fires were 25 to 31 percent more likely on Saturday or Sunday than on a weekday; however, the propensity for weekend fires was highly variable between locations. Areas that experienced extremely high levels of deliberate firesetting were not characterised by increased numbers of fires on weekends relative to weekdays.

- Overall, the majority of fires were small with the number of fires decreasing with increasing fire size.
- Natural fires and fires of unknown cause accounted for a disproportionate number of large fires. Deliberate fires accounted for a decreasing proportion of fires as fire size increased.
- Approximately 190,000 ha burned in TFS-attended fires from July 1999 to November 2004. The majority burned in 2002–03 (56,480 ha) and 2003–04 (104,583 ha).
- Less than 10 percent of the total area was burned in the Greater Hobart and Greater Launceston regions.
- Only 6.6 percent of the total burned resulted from deliberate fires. The greatest area burned in deliberate fires occurred in 2002–03 (3,790 ha) and 2003–04 (5,332 ha), but this comprised only five to seven percent of the total area burned in those seasons. Deliberate fires burned the highest proportion of land in those years where the total area burned was small.
- The majority of vegetation fires and the majority of the total area burned in TFS-attended fires occurred in native grassland. A high proportion of fires in hummocky grassland occurred in the Hobart region.
- There is some indication for increased incidence of deliberate fires during two periods of adverse bushfire weather in 2002–03 and 2003–04, but very different trends were evident for these two seasons. This may, at least in part, reflect arson prevention measures adopted in known hot spots during the latter season.

Sources of background information

ABS 2006. *Australian demographic statistics*. ABS cat. no. 3101.0. http://www.abs.gov.au/ausstats/abs@.nsf/cat/3101.0

ABS 2005a. *Population by age and sex, Tasmania*. ABS cat. no. 3235.6.55.001. http://www.abs.gov.au/ausstats/abs@.nsf/cat/3235.6.55.001

ABS 2005b. *Tourism region maps and concordance riles, Australia, 2005*. ABS cat. no. 9503.0.55.001. http://www.abs.gov.au/ausstats/abs@.nsf/cat/9503.0.55.001

Australia. Department of Environment and Heritage 2001a. *Land use: Tasmania*. Accessed through: http://audit.deh.gov.au/ANRA/atlas_home.cfm

Australia. Department of Environment and Heritage 2001b. *Native vegetation types and extent: Tasmania*. Accessed through: http://audit.deh.gov.au/ANRA/atlas_home.cfm

Australian Bureau of Meteorology 2007a. *Average minimum and maximum temperature maps: Tasmania*. Accessed through: http://www.bom.gov.au/climate/map/temperature/IDCJCM0005_temperature.shtml

Australian Bureau of Meteorology 2007b. *Average rainfall, annual: Tasmania*. Accessed through: http://www.bom.gov.au/cgi-bin/climate/cgi_bin_scripts/annual-monthly-rainfall.cgi

Ellis S, Kanowski P & Whelan R 2004. *National Inquiry into Bushfire Mitigation and Management*. Canberra: Commonwealth of Australia. http://www.coagbushfireenquiry.gov.au/findings.htm

EMA 2006. *EMA disasters database: February 1967 bushfires*. http://www.ema.gov.au/ema/emadisasters.nsf/c85916e930b93d50ca256d050020cb1f/85a9da8814839b4cca256d3300057b9e?OpenDocument

Australian Capital Territory

Contents

The first part of this Chapter provides **contextual information** on the Australian Capital Territory, including basic information about its climate, geography, land use and population. It also provides an outline of the bushfire regimes, historically important bushfire events, and overview of fire services in the Australian Capital Territory. The second part represents an **analysis of data** provided by the ACT Parks Conservation and Lands.

For an explanation of the key terms, limitations and methodology refer to the introduction, glossary and methodology chapters.

Introduction

The Australian Capital Territory consists of a small (2,400 square kilometres) landlocked enclave located in the Southern Tablelands of New South Wales.

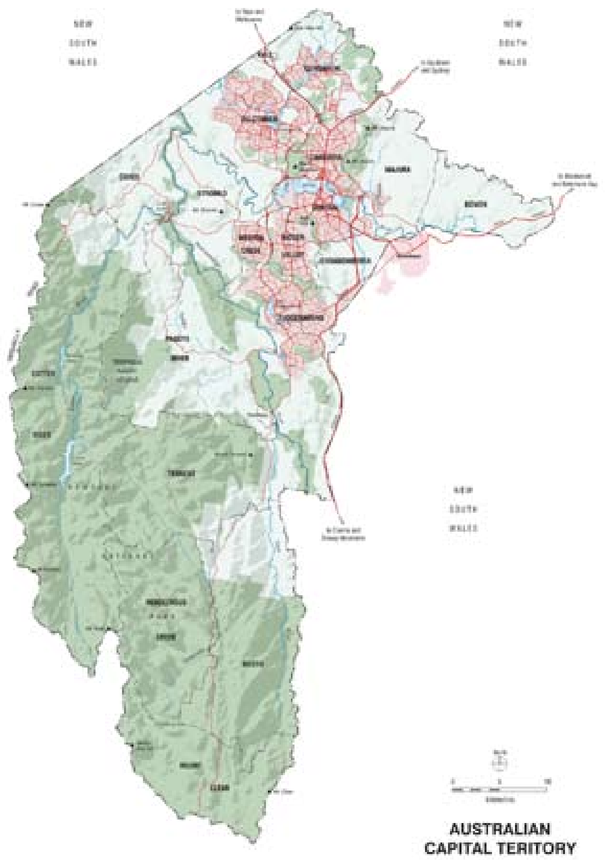
Geography

The western margin of the territory is bounded by the Brindabella Ranges (Figure 1), the northern extension of the Snowy Mountains and the highest expression of the Great Dividing Range. The mountain slopes commonly rise to 1,200 m, but in the south and west steep ridges and mountains peaks reach above 1,800 m. Most of the mountainous terrain in the southern and western parts of the territory is heavily forested and in the south, the comparatively untouched forests are preserved within the Namadgi National Park and the Tidbinbilla Nature Reserve. Beyond these areas lie the high country and the Snowy Mountains.

In the northeast the territory consists of low undulating hills and floodplains of the Murrumbidgee and Molonglo Rivers. Most of this area lies below 600 m in elevation. Within this area lies the city of Canberra, the capital of Australia and the only major urban development in the territory. Lying between the mountain and urban areas is a strip of land dominated by agriculture and forestry, scattered semi-rural residential areas, and small settlements (Williamsdale, Naas, Uriarra, Tharwa and Hall).

Canberra is a comparatively young city, with much of the urban area having been built in the last 30 to 50 years. It is commonly referred to as the bush capital, being surrounded by bushland or grassy plains on all sides, but with tracts of open land separating distinct parts of the city and neighbouring suburbs.

Figure 1: Map of the Australian Capital Territory



Map courtesy of Mapping Services, ACT Planning and Land Authority, January 2008

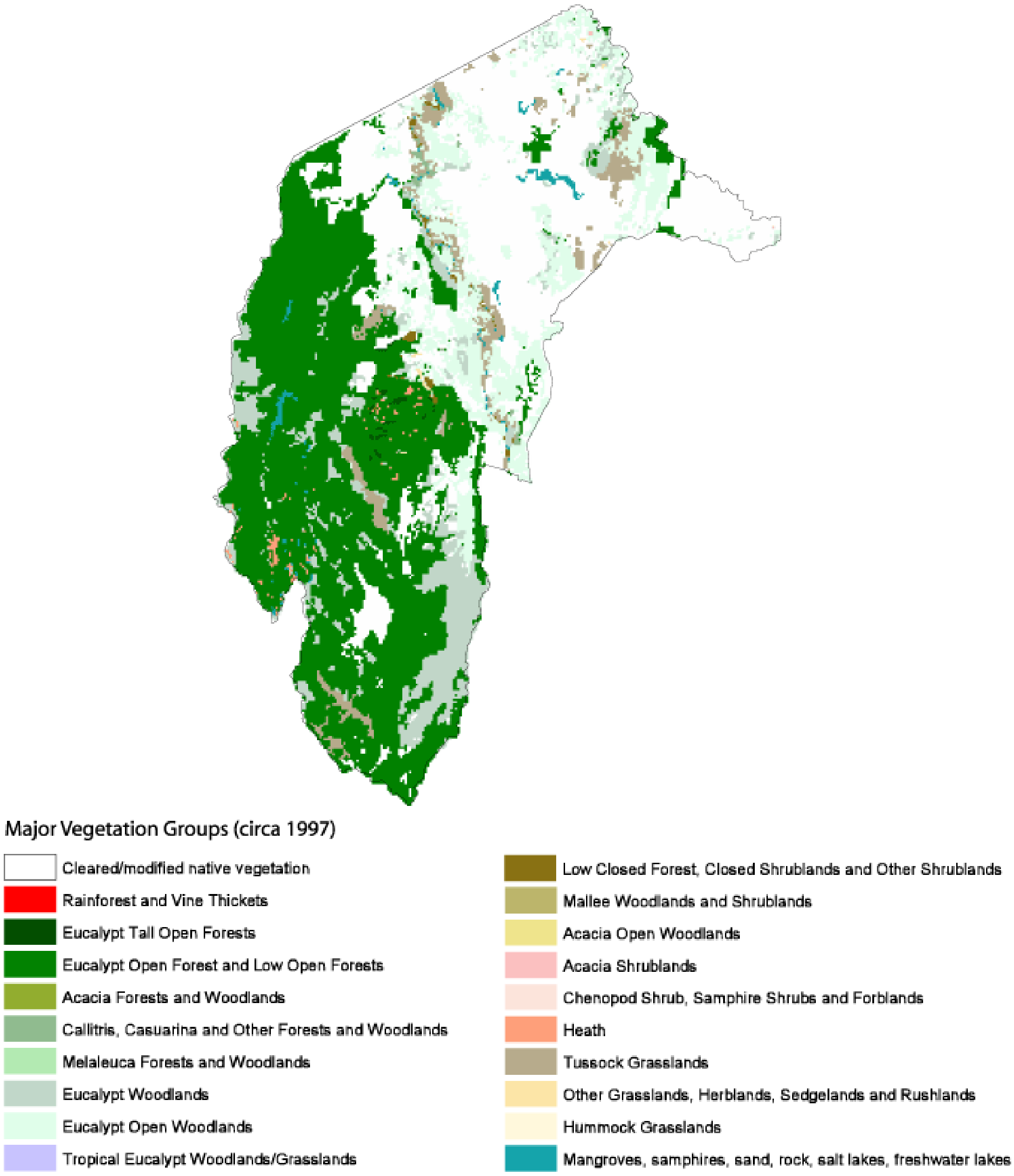
Climate

The territory experiences four distinct seasons. Owing to its distance from the coast, there are few moderating influences from coastal breezes, and the largely continental climate incorporates hot dry summers through to cold winters characterised by heavy fog and frequent frosts. The higher mountains of the west experience snow, and may remain snow-covered for at least part of the winter. Average annual rainfall in Canberra City is 633 mm, but greater than 800 mm is experienced in the western and southern mountainous regions (Australian Bureau of Meteorology 2007). Rainfall in the territory is uniformly distributed throughout the year, with winter precipitation principally related to the west to east movement of cold fronts across southern Australia. The low rainfall experienced in the territory and the Southern Tablelands, as compared to other parts of the Great Dividing Range, reflects rain shadow effects generated by the Snowy Mountains to the southwest. Summer rainfall is commonly derived from thunderstorms that can occur from October and March.

Native vegetation

Consistent with its location, major vegetation types in the territory are typical of those observed in bioregions of the Australian Alps and South East Highlands. Most of the west and south of the territory is dominated by eucalypt open forest and low open forest, eucalypt woodlands, with valleys of tussock grasslands, pockets of heath and eucalypt tall open forest (Figure 2). The little that remains of the original vegetation in the northeast is dominated by eucalypt open woodlands, with lesser amounts of tussock grassland, eucalypt open forest and low open forest, and eucalypt open woodlands (Department of Environment and Heritage 2001b).

Figure 2: Major vegetation groups (c. 1997)

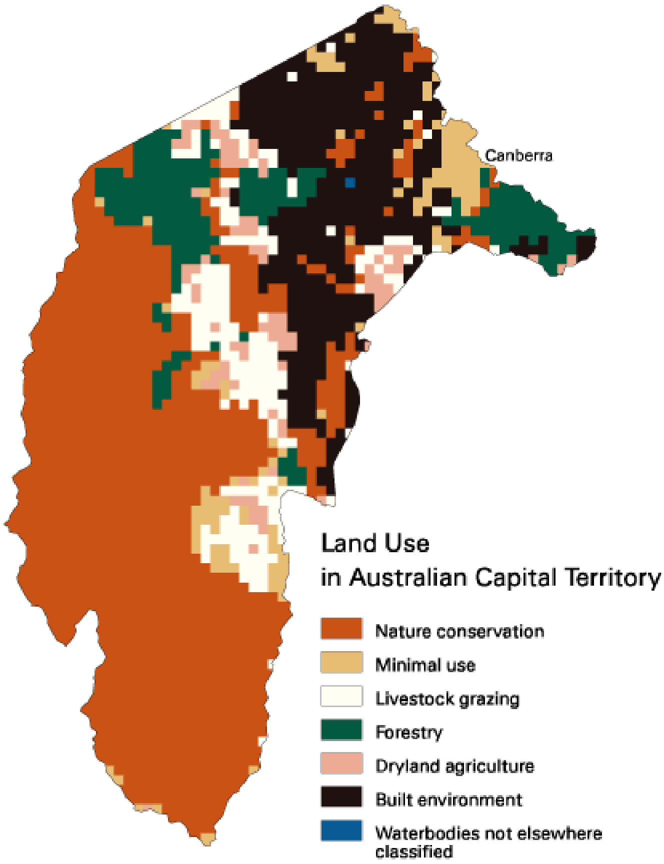


Source: Department of Environment and Heritage 2001b

Land use

As at 1996–97, 53 percent of the territory was used in nature conservation. This principally occurs in the southwest at Namadgi National Park and Tidbinbilla Nature Reserve, although smaller reserves are scattered across the territory, including through the urban centre itself (Figure 3). In 1996–97, forestry occurred on 10 percent of territory lands, with forestry reserves bounding both the Namadgi National Park and urban centres. However, much of this resource was lost during the 2003 bushfires. Dryland agriculture and livestock grazing, principally in the north and east, accounted for a further four and eight percent of the total area respectively.

Figure 3: Land use in the Australian Capital Territory (c. 1996–97)



Source: Department of Environment and Heritage 2001a

Population

As at June 2006, the territory's resident population was estimated to be 328,800 accounting for 1.6 percent of Australia's total population (ABS 2006b); the majority resides in the city of Canberra.

With a median age of 34.5 years (at June 2005), the territory's population is younger than the national average (median age of 36.6 years). The lowest median age occurs in the Gungahlin–Hall statistical subdivision (median age of 31.1 years), followed by Tuggeranong (33.1) and North Canberra (33.3) statistical subdivisions. As at June 2005, 19.2 percent of the territory's population was under 15 years of age. However, nearly one-quarter of people in the Gungahlin–Hall statistical subdivision (23.9%) and Tuggeranong statistical subdivision (23.6%) fell within this age bracket.

Overall, the territory has a lower proportion of people aged 60 years or older, but a higher proportions of people aged 16 to 58 years and young adults (18 to 33 years) than other jurisdictions. This reflects the high number of people within these age groups who move to Canberra for the purposes of tertiary education and/or employment (ABS 2005).

Bushfire regimes

Bushfire regimes in the territory are equivalent to those observed in most of the Snowy Mountains and South West Slopes. The bushfire season in the territory typically spans October to March being associated with the hot, dry summer conditions. However, deviations from this interval are facilitated by the sometimes erratic rainfall distribution.

Bushfire history

A detailed history of bushfires in the territory is available at the ACT Emergency Services Authority website at www.esb.act.gov.au. The most devastating bushfires and bushfire seasons are documented in Table 1, with a number of these discussed in more detail below (ACTESA 2006b).

1939: 3 to 14 January – November 1938 to mid January 1939 were the driest months on record since 1918. Fires broke out beyond Uriarra Station during heat-wave conditions, and by 14 January had reached the territory along three main tongues – one near Mount Franklin, one at Two Sticks Road (near Mount Coree) and the third near Horseshoe Bend along the northern boundary of the territory. Strong winds of up to 70 km per hour on the 14th fanned the flames and started numerous spot fires up to 24 km ahead. By Saturday afternoon the fire front was 72 km long and had crossed the Murrumbidgee River in several places, before being halted. Approximately 60,000 ha of timbered and grazing land were burned out (including 1100 ha of pine plantation, which at that time was worth £300,000. No lives were lost and stock losses were small. The main losses were property and approximately 64 km of fencing, particularly in the Tidbinbilla and Uriarra area.

1952: January to March – from 17 to 24 January six fires at Bobbys Plain, on the Brindabella–Tumut Road, burned 800 ha; all six were believed to have been deliberately lit. Another three fires (two ignited on the 25th; one ignited on the 23rd) burning in the Yarralumla (Campbell Fire), Red Hill (Jennings Fire) and Woden (Tanner Fire) areas combined, and over 12 days, racing across Mugga Hill and towards Tuggeranong, and subsequently across scrub country and into New South Wales. At least two of the three fires were attributed to power lines. These fires claimed two lives, burned two cottages, 40 sheds and out-buildings, machinery, haystacks, 357 acres of pines, thousands of hectares of fodder, five railway bridges, several hundred miles of fencing, and resulted in the deaths of approximately 7,000 sheep and other livestock. Subsequently, fires started by lightning strikes in the northwest of the territory, in pine forests near Mount Stromlo, and in the Hall District on 5 February, collectively burned thousands of hectares of grassland and some pine plantations. Lightning on 5 February was also considered responsible for fires near Baldy Mountain, California and Bag Range. These fires were not detected until 7 February and over several weeks burned 14,500 acres.

1979: 13 February 1979 – a bushfire broke out under extreme weather conditions near Hall. Fanned by 70 km per hour winds, the fire quickly spread, and by 5 pm the township of Sutton was evacuated, as the fire reached nearby hilltops. A subsequent wind changed caused the fire to break out towards the northeast, but it was contained the next day. The fire burned 16,500 ha in total, of which 4,025 ha was located in the territory. Two cottages, three sheds, machinery and stored fodder, about 5,000 sheep, six horses and fencing worth $200,000 were destroyed. A dropout fuse from a high-tension power line caused the fire. Other outbreaks on the same day occurred at Mount Painter, Tuggeranong, near Kambah Pool, and at Stirling.

1983: 9 to 30 January – A large fire broke out in inaccessible terrain in near Mount Kelly, in the southwest of the territory. A total of 36,000 ha burned, including 300 ha of pine plantations, but there was no loss of life or property. Large costs arose from attempts to suppress the fire as it burned over several weeks.

2003: 18 January – the territory, like much of Australia, experienced severe drought during 2002–03. On 8 January, lightning strikes started numerous fires to the west of Canberra, in both New South Wales (McIntyre Hut, Broken Cart and Mount Morgan) and the territory (Bendora, Stockyard Spur and Gingera). The fires burned for about a week in inaccessible terrain under high but not extreme fire conditions. Despite suppression operations the fires continued to grow. During extreme weather conditions on 17 January the fires broke containment lines. On the afternoon of 18 January, fires quickly spread, enveloping outlying rural settlements, farmland and forest before reaching the westernmost suburbs of Canberra. The behaviour of the fire was extraordinary. The speed of the fire meant fires penetrated deep into suburbs, with many houses lost through ember attack. The ferocity of the fires was compounded by a fire weather-generated tornado, which not only fanned the fire, spread embers, but also by itself caused extensive damage. The speed and ferocity of the attack surprised residents, fire agencies and fire experts alike, and fire authorities could do little to stop the blaze. The fires affected 70 km of the urban edge of Canberra, burned a total of 157,170 ha, of which 109,400 ha was in nature reserves, 16,770 ha in plantation forests, and 31,000 ha was in rural lands. The fires burned over 90 percent of the land managed by Environment ACT and 65 percent of the land managed by ACT Parks Conservation and Lands (ACTPCL). The fires resulted in four deaths, many injuries, loss of 488 dwellings, and nearly 100 other structures, and the deaths of 4,000 livestock. The insured cost has been estimated at $350 million.

Table 1: Fire history of the Australian Capital Territory

Date	No. of deaths	Area of fire (ha)	Losses	Location(s)
1951 December – 1952 February	2	10,000	2 houses, 40 farm buildings, several Observatory buildings, 450 ha of pine, 6 bridges, several hundred km of fences, 3 vehicles	Molonglo valley, Mount Stromlo, Red Hill, Woden Valley, Tuggeranong, Mugga Hill
1956 December – 1957 January		3,125	Primarily pasture and bushland	Ginninderra, Hall, Majura, Black Mountain, Tharwa
1979 February		16,500 (ACT, NSW)	2 houses, 3 sheds, machinery, fodder, 5000 sheep, 6 horses, $200,000 in fencing, fire tanker	Hall, Sutton, Mount Painter, Kambah Pool, Stirling
1982 September, 1983 March		36,000	300 ha of pine	Jervis Bay (Sept. 1982), Mount Ainslie, Bullen Range, Gudgenby area
1985 March	1	28,000 (10,000 in ACT)	Total damage of several million dollars, 7000 livestock	Mugga Lane, Red Hill, Mount Majura, Tharwa, Symonstown, Googong – Queanbeyan area of NSW (site of fatality)
2001 December		>1,600	500 ha of pine forest valued at several million dollars	Coppins Crossing, Yarralumla, Red Hill, Stromlo, Bruce Ridge, Oaks Estate, Wanniassa hills
2003 January	4	>157,000	450 injuries, 488 houses, 100 other structures, Mount Stromlo Observatory, 4,000 stock, 16,770 ha of pine plantations, 4 bridges, 300 vehicles, total damage >$350m	Namadgi National Park; Uriarra, Pierces Creek and Stromlo settlements; Cotter, Corin, Tidbinbilla, Mount Stromlo, Duffy, Holder, Chapman, Kambah, Curtin, Lyons, Murrumbidgee Valley, Coppins Crossing

Source: Ellis, Kanowski & Whelan 2004

Fire services

The two principal agencies that provide fire services in the territory are the ACT Fire Brigade and the ACT Rural Fire Service.

The **ACT Fire Brigade** forms one arm of the ACT Emergency Services Agency. It attends all types of structural, transportation and bush and grass fires, as well as other emergencies such as industrial and road accidents, hazardous chemical spills, and storm damage operations. Fire services principally cover the urban area. As at 2005–06, the ACT Fire Brigade comprised 316 full-time professional fire fighters and 28 community fire units with approximately 650 volunteers (ACTESA 2006a). Further information about the ACT Fire Brigade can be found at www.firebrigade.act.gov.au.

The **ACT Rural Fire Service** (ACTRFS) is responsible for suppressing bush and grass fires within rural and remote areas of the territory. As at 2005–06 there were 11 permanent staff, eight Rural Fire Brigades with approximately 370 volunteers and one brigade staffed by the ACT Parks Conservation and Lands (ACTPCL), part of Environment ACT, with approximately 120 departmental firefighters (ACTESA 2006a). The ACTRFS falls under the umbrella of the ACT Emergency Services Agency; it undertakes operational planning with the ACT Fire Brigade, attends fires outside of the city area and provides operational support for other agencies. Further information can be found at www.rfs.act.gov.au.

As the territory's data analysis was restricted to a dataset provided by ACTPCL, there is incomplete coverage for rural areas, and no analysis was undertaken for fires in the territory's urban areas.

ACT Parks Conservation and Lands analysis

Background about the ACTPCL dataset and its analysis

The ACTPCL database principally incorporates vegetation fires that occurred on or threatened reserves, conservation areas and other parklands in the territory from 1975–76 to 2002–03, but also includes 54 rural vegetation fires, 22 urban vegetation fires, 26 vegetation fires that occurred in New South Wales and one instance listed simply as ACT. Although this dataset includes some information about fires attended by the ACTRFS, it does not provide complete coverage for all vegetation fires attended by that agency in non-urban regions of the territory. Nor does it include fires on federal lands at Jervis Bay, a distinct enclave of land within New South Wales that formed part of the territory before self-government was declared in 1988. The analysis draws on historical records of vegetation fires (frequency and total area burned) documented on the Firebreak website to highlight differences between the ACTPCL data and vegetation fires in non-residential areas. Firebreak is a newsletter published online by the ACT Volunteer Brigades Association (ACTVBA), hosted on the ACT Emergency Services Authority website (ACTESA 2006b). Additional points about the analysis and dataset include:

- The database does not use the Australasian Fire Authorities Council AIRS codes.
- Fire cause was based on the 'ignition factor' variable provided; this is not equivalent to the AIRS ignition factor variable.
- The database does not generally include urban vegetation fires (hedge fires, fires on the local oval, etc.), other than if those fires were genuinely within or threatened nature reserves and vegetated parklands.
- The ACTPCL database provided included nine causal categories; accidental, lightning, barbecue, arson, prescribed burn, prescribed burn–reignition, reignition, other and unknown.
- Vegetation fires identified as arson were labelled incendiary in the seven-fold classification scheme adopted in this analysis. These are referred to as deliberate fires throughout much of the text; that is arson = incendiary = deliberate.

- Vegetation fires attributed to prescribed burns and reignition were incorporated into a single category. It is unclear to what 'prescribed burns' documented in this database represent a controlled situation as opposed to an escape of a controlled burn.
- Unlike other jurisdictions, the spatial distribution of vegetation fires is charted in terms of districts (Figure 1) as opposed to regions; the district information is as provided, with only subtle modifications having subsequently been made (see methodology).
- A 'remoteness' classification incorporating five categories – urban, urban fringe, rural, remote and unknown – was defined on the location of the reserve relative to the major population centre of Canberra (see methodology).
- Information was included about the location (reserve, district), timing (date), and area burned by vegetation fires.
- No information was given about fire restrictions or fire danger index.

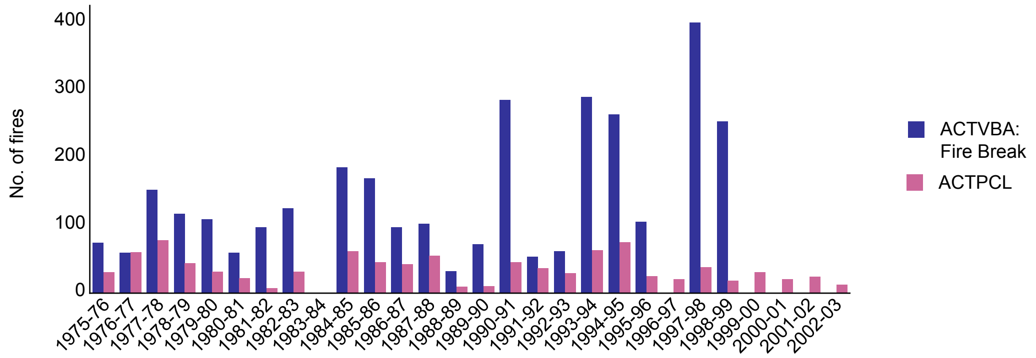
For more detail about these methodologies see the methodology chapter.

Overview

Overall characteristics of fires included within the ACTPCL database can be summarised as:

- The ACTPCL database comprised 988 vegetation fires from 1975–76 to 2002–03, with an average of 35.3 fires per year (sd=20). The number of vegetation fires peaked at >70 in 1977–78 and 1994–95 and at >60 in 1976–77, 1984–85, and 1993–94. The lowest number of vegetation fires (less than 10) occurred in 1981–82 and 1983–84, years bracketing 1982–83, in which drought pervaded much of the Monaro region. Despite the widespread devastation of the January 2003 fires, and possibly because of that devastation, vegetation fire numbers reported for 2002–03 were also exceptionally low. Despite this variation, the number of vegetation fires each year oscillated about a comparatively stable mean, although comparatively low numbers of vegetation fires have been recorded since the mid 1990s. This is in marked contrast to trends the ACTVBA (Firebreak) recorded over the same interval, where elevated numbers of fires have been evident since the early 1990s. In 1997–98, Firebreak documented 400 fires (Figure 4).
- Sixty-nine percent of vegetation fires recorded by ACTPCL were deliberate; representing 70 percent of assigned causes.
- Almost 80 percent of all fires occurred in or near urban and semi-urban areas; these areas were characterised by higher rates (number and proportion) of deliberate fires than rural and remote districts.
- A total of 377,000 ha was burned, mostly during 2002–03; only 11 percent of this was burned in deliberate fires.

Figure 4: Fires per year, by ACTPCL and ACT Emergency Services Authority (Firebreak) (number)[a]



a: data were unavailable in Firebreak for vegetation fires during 1996–97 and for 1999–2000 onwards

Source: ACTPCL 1975–76 to 2002–03 [computer file] and Firebreak, ACTESA 2006b

Cause

Almost 70 percent of vegetation fires documented in the ACTPCL database between 1975–76 and 2002–03 were incendiary (Figure 5). A further 19 percent of vegetation fires were prescribed burns or reignition of previous vegetation fires. Lightning strikes were responsible for eight percent of vegetation fires attended, with just over two percent being accidental in origin.

Some notable changes are evident in the cause of vegetation fires through time. During the later half of the 1970s and early 1980s deliberate (incendiary) causes accounted for approximately 60 percent of the ACTPCL fires in any given year (Figure 6). However, for most of the 1980s and 1990s the rates were over 80 percent. The proportion of deliberate vegetation fires recorded in the ACTPCL database was generally lower during the late 1990s and this century, although in 2001–02 the rate was again over 80 percent. In 2002–03, only 31 percent (n=4) of ACTPCL fires were identified as deliberately lit.

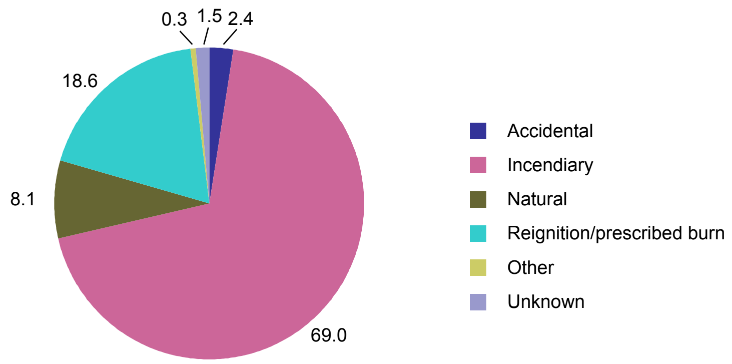
The actual number of deliberate vegetation fires documented in the ACTPCL database was highly variable between years, with the highest number occurring in 1993–94 and 1994–95 (approximately 60 fires per year). A higher than average number of deliberate vegetation fires also occurred during the 1970s and mid 1980s. A low number of deliberate vegetation fires (less than 20) were documented for 1995–96 onwards. The large fluctuation in total number of fires and frequency of deliberate fires from year to year tends to obscure long-term changes in the role of deliberate firesetting, with higher rates being evident since the mid 1980s. The average proportion of deliberate fires (determined from the slope of the line in Figure 7) from 1975–76 to 1984–85 was 49 percent, as compared with an average of 88 percent deliberate lightings for 1985–86 to 2002–03. Note that, a higher percentage of deliberate causes does not necessarily translate as a greater number of deliberate vegetation fires, at least in ACTPCL data. However, this may not have been the case in other jurisdictions.

The ACTVBA (Firebreak) documented higher numbers of fires during the 1990s. If similar rates of deliberate fires are equivalent to those documented by ACTPCL, then it is possible that almost 350 fires in 1997–98 attended by that agency may have may have been deliberately lit. The differences in numbers of fires recorded by the ACTVBA and ACTPCL, may relate to changes in where people chose to light fires (or jurisdictional changes) rather than a real decrease in actual numbers of deliberate fires. Clearly, greater investigation into the actual incidence and cause of territory vegetation fires is needed to ascertain if this is the case.

Between 35 and 40 percent of vegetation fires (12 to 32 fires per year) from 1975–76 to 1978–79 were identified as prescribed burns. However, during subsequent years, prescribed burns accounted for less than 10 or 15 percent of documented vegetation fires. The notable exception was from 1997–98 to 1999–2000 where this cause accounted for between one-quarter and two-thirds of the documented fires in a given year.

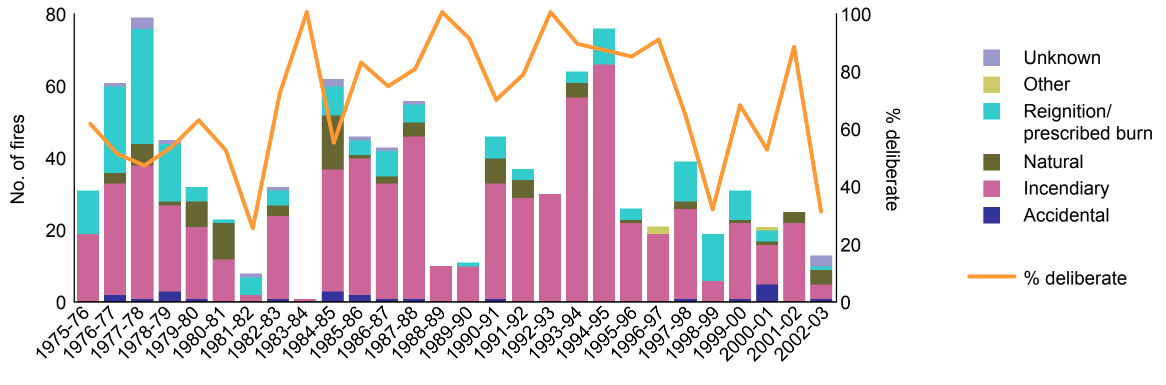
The number of natural vegetation fires caused by lightning strikes was also highly variable across bushfire seasons, ranging between 0 and 15 fires per year (Figure 8). Unlike for many jurisdictions, there was no clear relationship between increased number of natural fires and years in which there were El Niño events. However, interpretation may be clouded by the fact that multiple fires arising from the same thunderstorm system may be documented as a single fire event. This is certainly the case for 2002–03.

Figure 5: Cause of fires (percent)



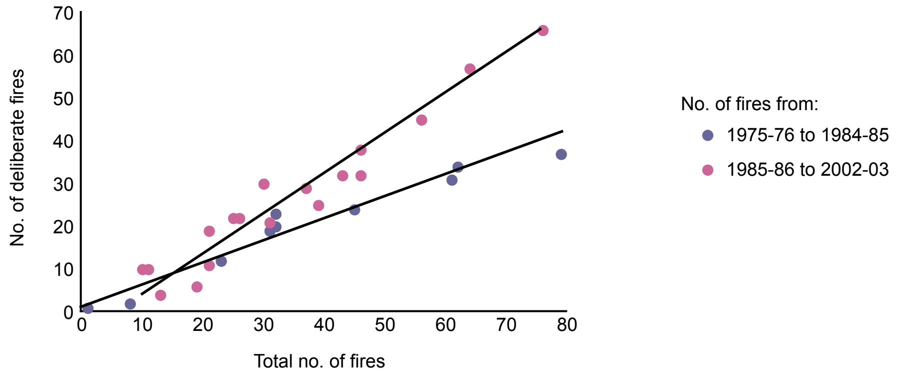
Source: ACTPCL 1975–76 to 2002–03 [computer file]

Figure 6: Cause of vegetation fires, by year



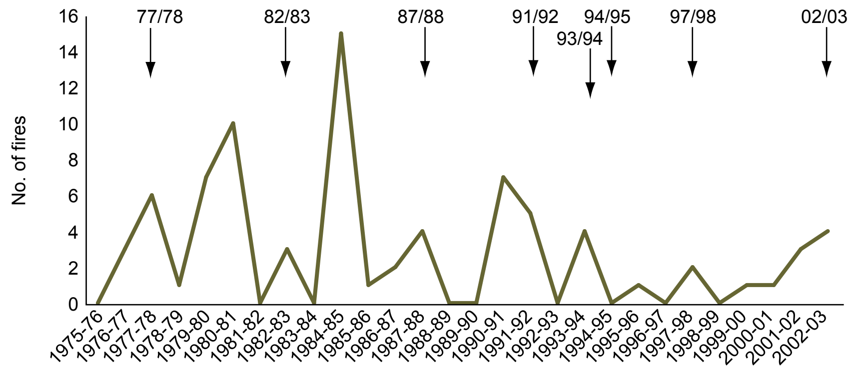
Source: ACTPCL 1975–76 to 2002–03 [computer file]

Figure 7: Deliberate and total fires each year for 1975–76 to 1984–85 and 1985–86 to 2002–03 (number)



Source: ACTPCL 1975–76 to 2002–03 [computer file]

Figure 8: Fires started by lightning strikes each year[a] (number)



a: numbers annotating the graph indicate years for which the Australian Bureau of Meteorology documented a Southern Oscillation Index lower than –10, years recorded as an El Niño event)

Source: ACTPCL 1975–76 to 2002–03 [computer file]

Location

The location of fires is examined according to the remoteness and the district in which fires occurred, and by reserve for selected regions that experienced higher numbers of fires.

Remoteness and district

More than three-quarters of all fires document in the ACTPCL database occurred either within reserves in urban areas (61%) or reserves on the urban fringe (18 percent; Figure 9). Just 13 and 5 percent occurred in remote and rural (includes forestry plantations) locations, respectively. This is reflected in the observation that most fires occurred in the Tuggeranong (24%; Figure 10), Central Canberra (17%), Belconnen (12%) and Woden Valley (9%) districts; all areas within or in close proximity to urban areas (Figure 1).

A high proportion of all vegetation fires that occurred in urban and semi-urban areas were deliberate, as compared with non-urban areas. Between 80 and 95 percent of fires within largely urban districts were deliberately lit (Figure 11). The notable exception was Weston Creek (58% deliberate), where there were a higher proportion of prescribed burns associated with managing neighbouring pine forests. One of the implications of Canberra's youth and large expansion since the 1950s is that the urban–rural interface has migrated substantially over time, affecting the distribution of vegetation fires.

The total number of deliberate vegetation fires in rural and remote regions was very low during the reporting period. The highest number of deliberate fires occurred in the Stromlo and Paddy's River districts. Deliberate fires were responsible for 77 and 35 percent of vegetation fires in these districts, respectively.

Reserve

Only five reserves recorded in excess of 50 fires in 28 years; Namadgi National Park (n=127), Mount Taylor (n=98), Black Mountain (n=78) Murrumbidgee Corridor (n=66), and Mount Ainslie (n=64; Figure 12). The majority of reserves bounded by urban development recorded an exceptionally high level of deliberate fires. For example, 87 of the 98 fires on Black Mountain were documented as incendiary. In contrast, approximately 90 percent of fires in the Namadgi National Park were non-deliberate in origin. Other areas to record a comparatively high level on non-deliberate fires included Tidbinbilla, and Googong Foreshores.

Tuggeranong district: Fifty of the vegetation fires in the Tuggeranong district occurred on the Mount Taylor reserve (the other 48 fires on Mount Taylor were included in the Woden Valley district). Comparatively high numbers of fires were also observed at Urambi Hills, Pine Island, Wanniassa Hills and Cooleman Ridge (Figure 13). With the exception of the Urambi Hills and Cooleman Ridge reserves, a high proportion of all vegetation fires lit in reserves in the Tuggeranong district were deliberate.

Thirty-six of the 50 fires recorded on the Mount Taylor Reserve in the Tuggeranong district occurred in the three seasons encompassing 1975–76 to 1977–78. These dominantly occurred over a short duration within any given year, in a period of intensive firesetting. Although some occurred during the bushfire danger period, others were in autumn and winter. Higher number of fires also occurred, albeit to a lesser degree, on neighbouring reserves (within walking distances of 2 to 3 km) during the same period. The timing of these fires directly overlaps with activity observed in the Mount Taylor Reserve and on several occasions fires were lit in two separate reserves on the same day. The timing of fires and the distribution along the three major ridges in the area implies the operation of a serial fire setter living in close proximity at that time. Fires lit on the Mount Taylor, Cooleman Ridge, and Urambi Hills Reserves and at Mount Taylor horse paddocks, were comparatively large given their location on the then margin of urban develop. Fifteen of the 39 fires burned 5 ha or more for the interval from 1975–76 to 1977–78; seven of these fires burned between 10 and 49 ha. Noteworthy is that elevated numbers of fires were also documented for the Woden Valley (also on Mount Taylor) from 1975–76 to 1977–78. This potentially indicates an even higher level of serial arson than outlined above.

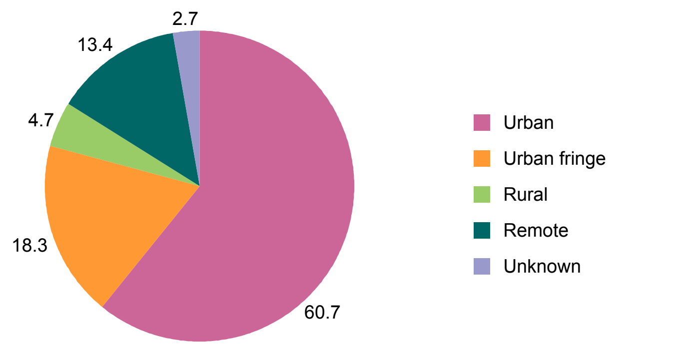
Central Canberra district: Black Mountain experienced the highest number of fires of any reserve in the Central Canberra District (Figure 14). Fifty-eight of the 76 (two other Black Mountain fires fell within the Belconnen district) were deliberately lit. A high proportion of fires on most other reserves in the district were deliberate (commonly 90%).

Many of the deliberate fires on the Black Mountain Reserve occurred during the three years encompassing 1993–94 to 1995–96; 46 of the 58 deliberate fires on that reserve occurred in these years, with 24 deliberate fires being lit in the 1994–95 season alone. This represents one-third of all fires that occurred in the Black Mountain reserve in the 28 years. Deliberate fires principally occurred during March and late July to mid September. Fires in 1995–96 primarily occurred during two consecutive weeks in early December.

The concentration of deliberate fires within a small area during restricted intervals implies that these fires are likely to have been the result of serial firesetting. As observed for fires in the Tuggeranong district, an increased number of fires occurred on the neighbouring Bruce Ridge and O'Connor Ridge reserves during the same intervals. The patterns of deliberate fires from 1993–94 to 1995–96 are consistent with an escalation from random infrequent fire lighting to intense periods of frequent and sustained fire lighting activity, with an abrupt decrease in the number of fires in November–December 1995.

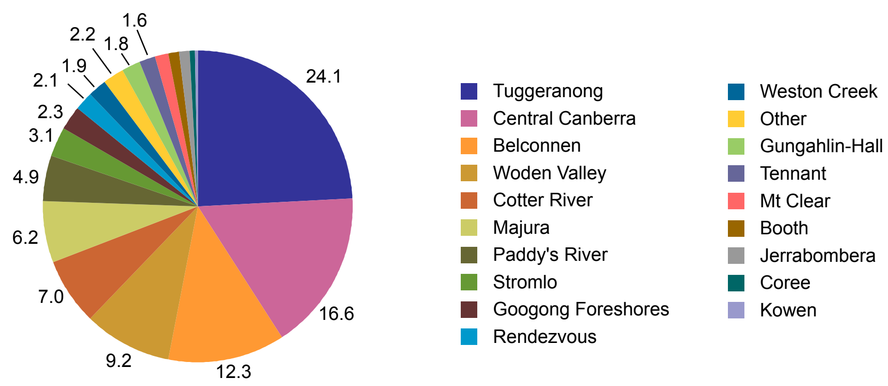
Belconnen district: Fires in the Belconnen district were more evenly distributed across reserves in the area. The reserves that experienced the most fires were The Pinnacle (n=18), Aranda Bushland and Bruce Ridge (Figure 15). High rates of deliberate fires occurred across most reserves in the district. Higher numbers of non-deliberate fires occurred on the Aranda Bushland and to a lesser extent at Gossan Hill.

Figure 9: Type of environment (percent)



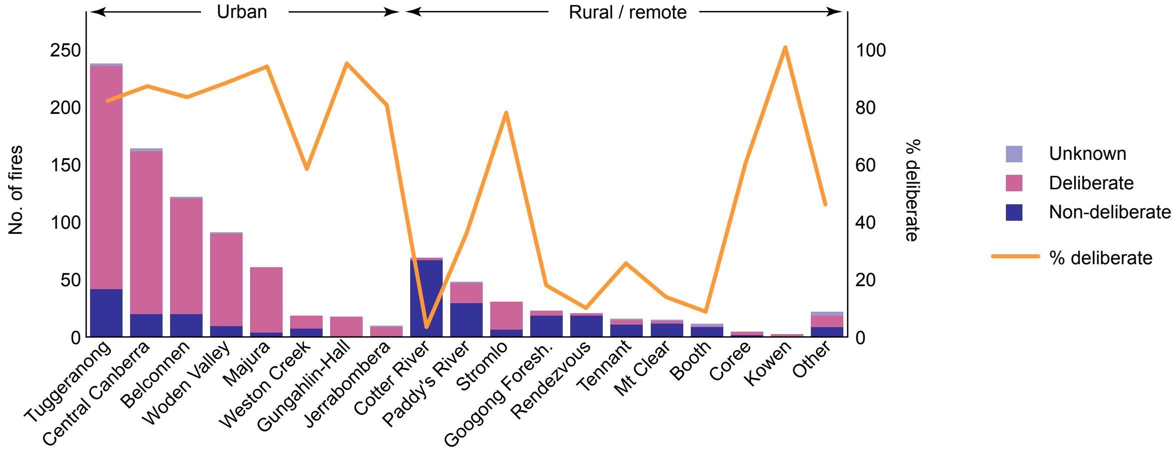
Source: ACTPCL 1975–76 to 2002–03 [computer file]

Figure 10: All vegetation fires, by district (percent)



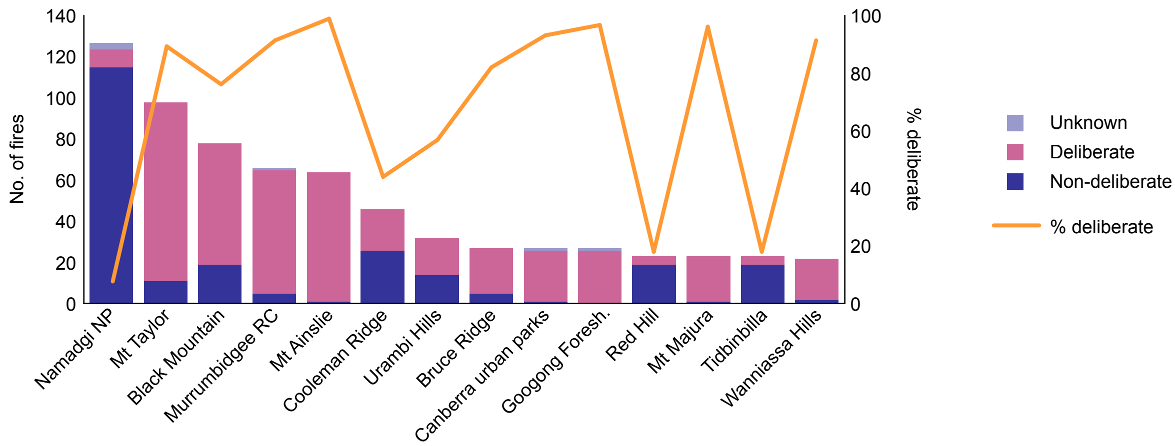
Source: ACTPCL 1975–76 to 2002–03 [computer file]

Figure 11: Cause of vegetation fires, by district



Source: ACTPCL 1975–76 to 2002–03 [computer file]

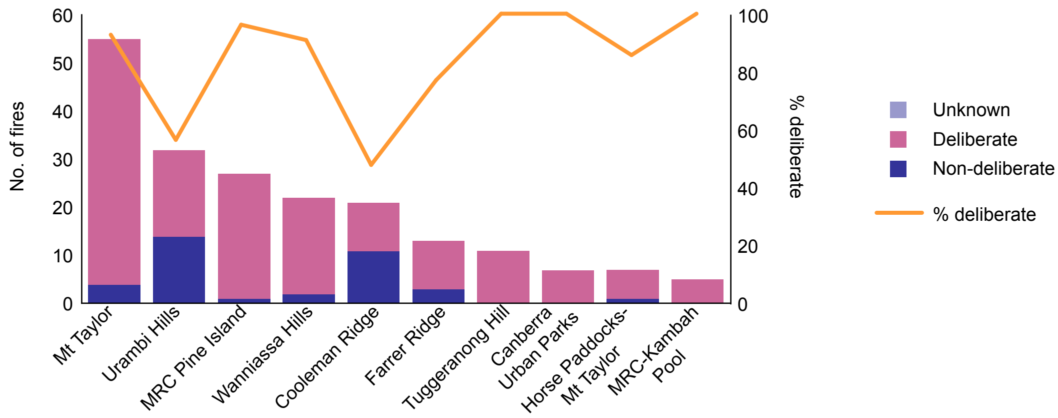
Figure 12: Cause of vegetation fires, by reserve[a]



a: only includes reserves documenting in excess of 20 fires during the observation interval

Source: ACTPCL 1975–76 to 2002–03 [computer file]

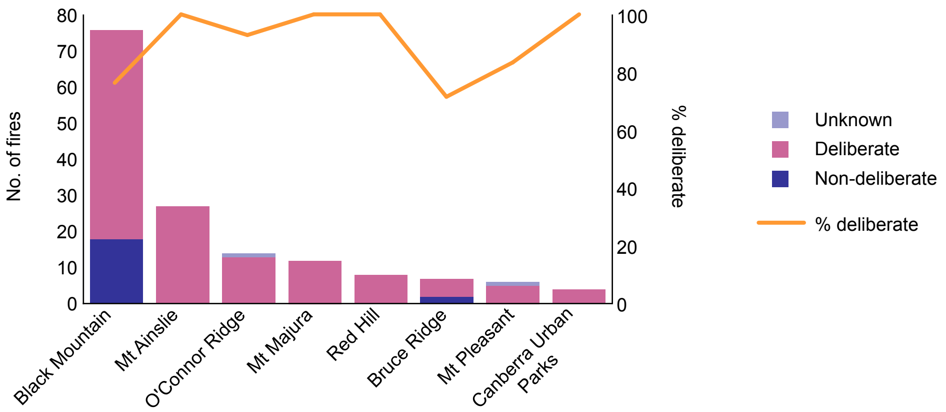
Figure 13: Cause of fires on reserves in the Tuggeranong district[a]



a: does note include 48 fires that occurred on Mount Taylor included in the Woden Valley district

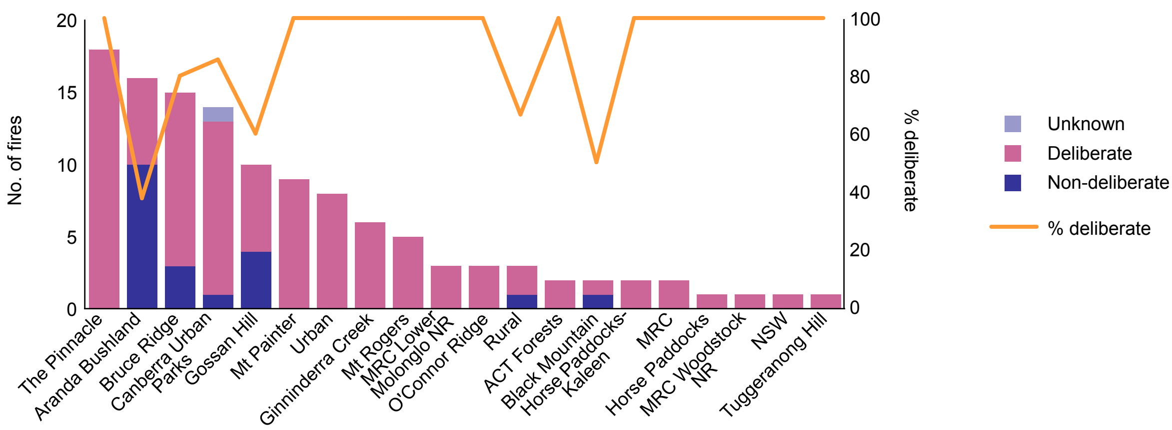
Source: ACTPCL 1975–76 to 2002–03 [computer file]

Figure 14: Cause of fires on reserves in the Central Canberra district



Source: ACTPCL 1975–76 to 2002–03 [computer file]

Figure 15: Cause of fires on reserves in the Belconnen district[a]



Source: ACTPCL 1975–76 to 2002–03 [computer file]

Timing

The timing of fires is examined by week of the year and day of the week.

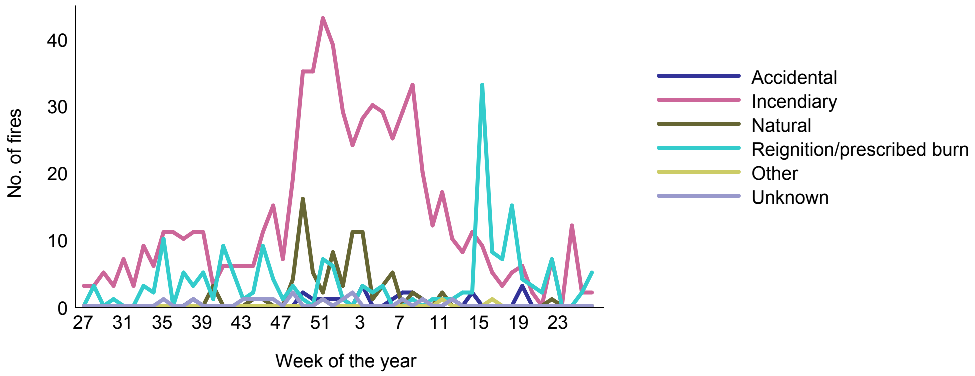
Week of the year

The vast majority of vegetation fires in the territory occurred from October to March, coinciding with hot and typically dry conditions that commonly characterise late spring, summer and in some cases early autumn in this region (Figure 16). Some differences in the timing of fires were evident, based on cause. Most natural fires on territory reserves occurred between mid December and mid February. The majority of prescribed burns occurred outside this danger window, principally during autumn, and to a lesser degree winter and spring (late April to November).

The greatest number of deliberate vegetation fires coincided with the most adverse bushfire danger period; the peak numbers of natural fires, but the number of deliberate fires remained elevated until the middle of March.

Although most fires in the territory occurred during the summer months, the timing of bushfires from year to year was highly variable. This reflects the highly erratic and unpredictable nature of rainfall in the Southern Tablelands region.

Figure 16: Week of the year[a], by cause (number)



a: week 1 corresponds to the first week of January

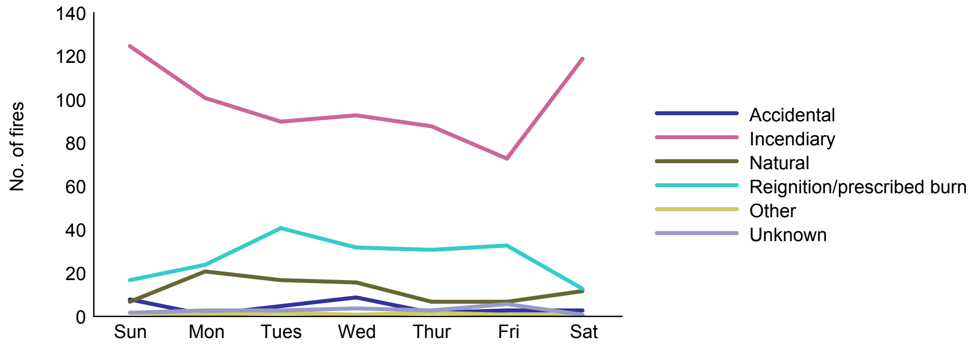
Source: ACTPCL 1975–76 to 2002–03 [computer file]

Day of the week

The distribution of fires throughout the week varied considerably across causal categories. For deliberate fires a trend of increased numbers of fires on weekends is superimposed on an overall trend of decreasing fire frequencies as the week progressed (Figure 17). Deliberate vegetation fires were 41 percent more likely to occur on Sundays and 34 percent more likely to occur on Saturdays relative to the weekday average. This was particularly evident for the Tuggeranong district where deliberate fires were 55 to 60 percent more likely on Saturdays and Sundays than on the average weekday (Figure 18). In contrast, the number of fires in the Central Canberra district appears to decline from Sunday through to Saturday.

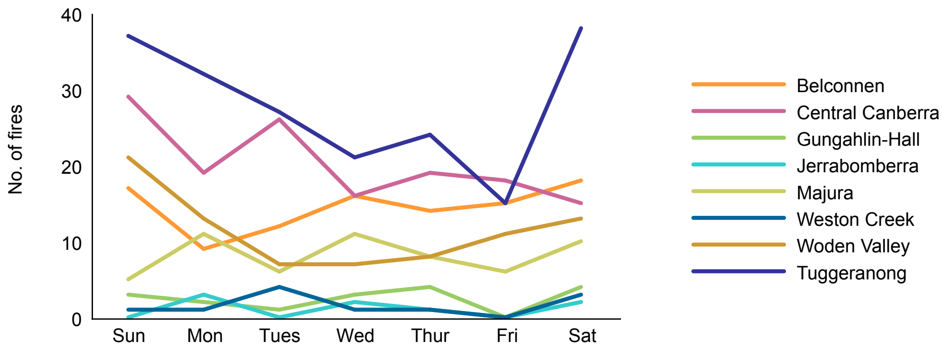
Given the comparatively low total number of fires documented for territory reserves, and that serial arson potentially accounts for a high number of fires in the Mount Taylor and Black Mountain areas, there is a high potential for the ‘pattern’ of a particular serial fire setter to strongly affect the principal timing of fires within that district. For example, half of all fires lit on the Mount Taylor, Cooleman Ridge and Urambi Hills reserves and at the Mount Taylor Horse Paddocks from 1975–76 to 1978–79, were lit on weekends. In contrast, only 16 of the 66 deliberate fires that occurred in Black Mountain, Bruce Ridge and O’Connor Ridge reserves from 1993–94 to 1995–96 were on weekends, and of those that did occur on weekends, most were on Sundays.

Figure 17: Day of occurrence, by cause (number)



Source: ACTPCL 1975–76 to 2002–03 [computer file]

Figure 18: Day of occurrence, by district (number)



Source: ACTPCL 1975–76 to 2002–03 [computer file]

Area burned

The majority of fires attended on territory reserves were small, with 44 percent being less than one hectare and 70 percent less than five hectares in area. Overall, the number of vegetation fires within each area category decreased with increasing fire size, but a comparatively high number of fires still fell within the 10 to 500 ha range (Figure 19). This trend was evident for all fire causes with the exception of prescribed burns/reignitions, where five to 50 ha fires dominated. Large vegetation fires were comparatively rare in the territory with only 20 fires burning 500 ha or more in the 28-year fire history documented in the ACTPCL database.

Deliberate fires accounted for a decreasing proportion of fires within each area category as the size of the fires increased (Figure 20); that is deliberate fires were typically smaller than non-deliberate fires. However, that relationship breaks down to some extent for very large fires owing to poor representation of fires of those size categories. Deliberate fires accounted for 35 percent of the ACTPCL fires exceeding 500 ha. Of the seven deliberate fires that exceeded 500 ha, the three largest occurred during 1984–85, burning 18,800 ha, 5,620 ha and 4,380 ha in the Tuggeranong (urban fringe), Majura (urban) and Googong Foreshores (urban fringe) districts, respectively. Another deliberate fire during the same year burned 588 ha near Jerrabomberra (rural). A deliberate fire burned 1,100 ha in New South Wales, close to the territory's urban border, in 1977–78. Another deliberate fire burned 1,950 ha in the Cotter River area (remote) in 1978–79. The only deliberate fire larger than 500 ha since the mid 1980s burned 1,230 ha in the Stromlo area, on the urban fringe, in 2001–02.

Consistent with the frequency distributions described above, fires resulting from prescribed burns/reignition accounted for an increasing proportion of fires as area size increased. However, only three prescribed burns exceeded 2,000 ha; all three occurred in New South Wales in either 1975–76 or 1976–77. The largest prescribed burn recorded in the database since 1995–96 burned 88 ha of rural property in the Belconnen area.

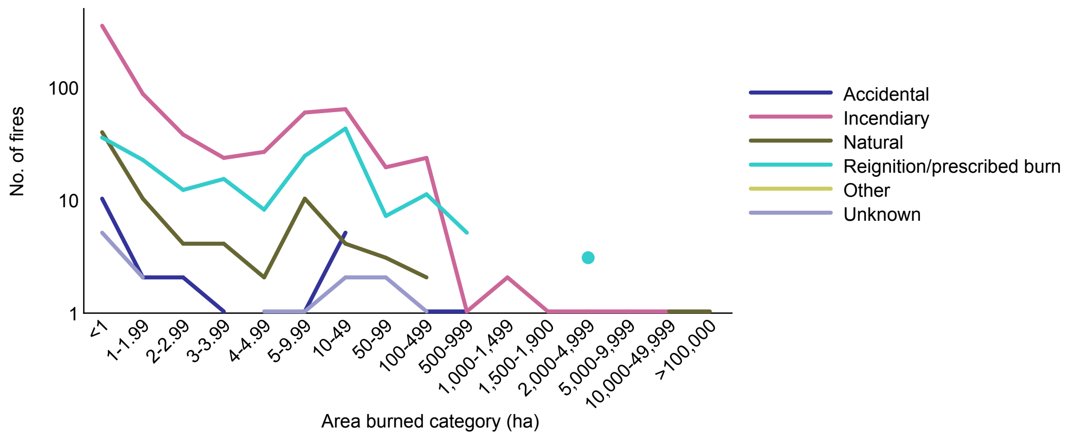
According to the ACTPCL database, fires started by lightning fell into two categories, either comparatively small (less than 500 ha) or very large. In 1982–83 fires started by lightning strikes burned 33,900 ha near Mount Kelly (Tennant). In 2002–03 numerous fires started by lightning to the west and southwest of Canberra burned 266,000 ha in the territory and New South Wales.

Approximately 377,000 ha were burned in ACTPCL-attended fires from 1975–76 to 2002–03. Statistics based on the total area burned are shaped by large fires events. Not surprisingly, fires started by lightning strikes accounted for 80 percent of total area burned in ACTPCL-attended fires (Figure 21). Seventy-one percent of the total area affected since 1975–76 was burned during 2002–03 (266,016 ha), with a further 9.2 percent (34,600 ha) of the total burned in 1982–83, reflecting the large areas burned by natural fires in those seasons (Figure 22).

Deliberate causes accounted for 11 percent of the total area burned (Figure 21), principally due to the series of large fires that occurred during 1984–85; deliberate fires collectively burned 31,600 ha in that year (Figure 23). Another 1,050 ha and 2,510 ha were burned in deliberate fires in 1977–78 and 1978–79, with 2,160 ha burned in deliberate fires during the 2001–02 season.

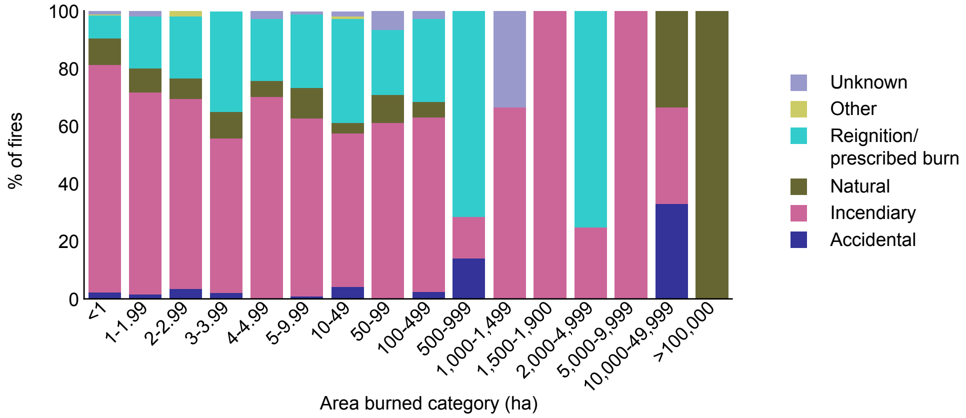
Prescribed burns and to a much less extent reignitions were collectively responsible for 3.9 percent of the total area burned in ACTPCL fires (Figure 21). The majority was burned in the large prescribed burns of the mid 1970s, principally 1975–76 and 1976–77 (Figure 24). A single large accidental fire burning 16,300 ha was responsible for the large area burned in 1978–79 (16,400 ha).

Figure 19: Area burned category, by cause (number)



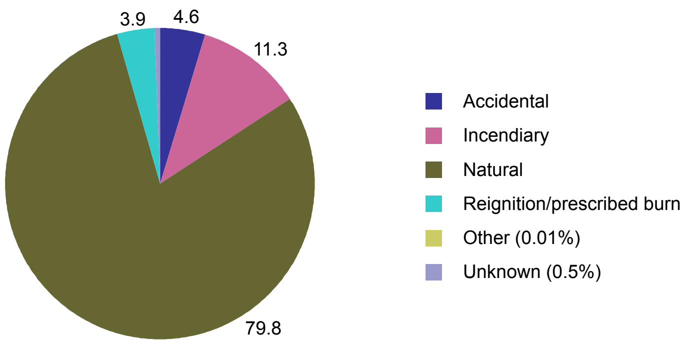
Source: ACTPCL 1975–76 to 2002–03 [computer file]

Figure 20: Area burned category, by cause (percent)



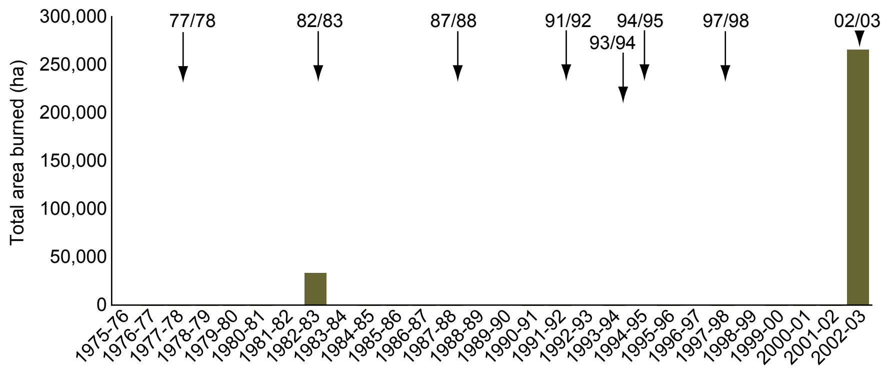
Source: ACTPCL 1975–76 to 2002–03 [computer file]

Figure 21: Total area burned, by cause (percent)



Source: ACTPCL 1975–76 to 2002–03 [computer file]

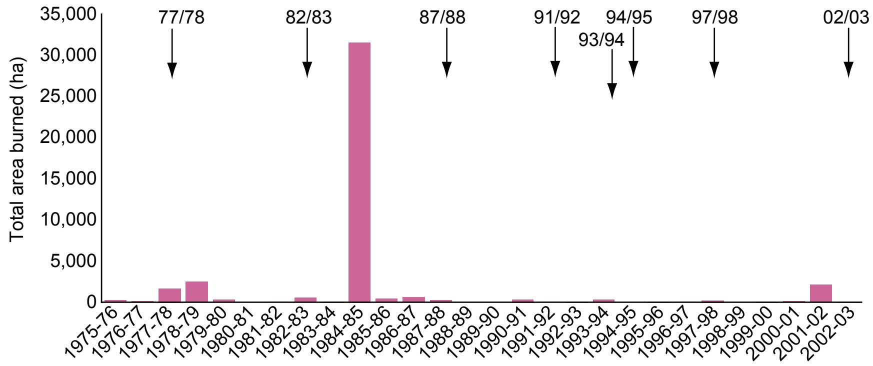
Figure 22: Total area burned (ha), by natural fires each year[a] (number)



a: annotated numbers indicate the timing of El Niño event (Bureau of Meteorology); numbers in red indicate years associated with severe drought

Source: ACTPCL 1975–76 to 2002–03 [computer file]

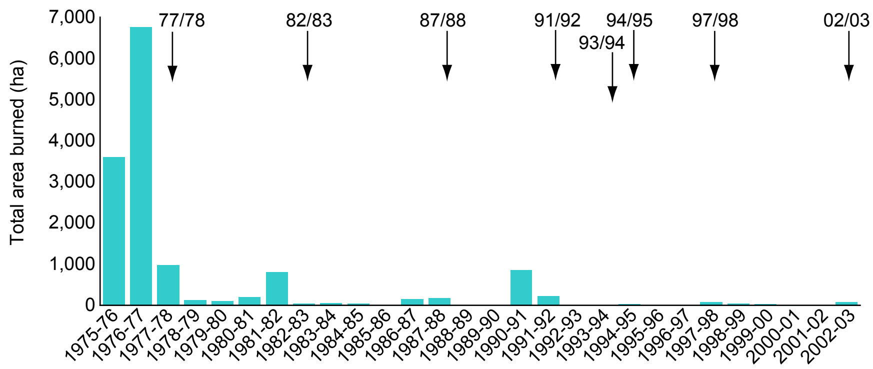
Figure 23: Area burned (ha) in deliberate vegetation fires, by year[a] (number)



a: annotated numbers indicate the timing of El Niño event (Bureau of Meteorology)

Source: ACTPCL 1975–76 to 2002–03 [computer file]

Figure 24: Total area burned by prescribed burns (majority) and reignition of previous fires, by year[a] (number)



a: annotated numbers indicate the timing of El Niño event (Bureau of Meteorology)

Source: ACTPCL 1975–76 to 2002–03 [computer file]

Relationships to climatic variations

Number of fires: There is not a strong correlation between the total number of vegetation fires recorded in the ACTPCL database and El Niño events (Figure 25). To a certain extent this is also evident for the historical data recorded in Firebreak. Although the Firebreak records indicate higher numbers of fires during 1993–94, 1994–95 and 1997–98, all seasons associated with El Niño events. This is not as evident for 1982–83, 1987–88 or 1991–92 and to a lesser extent 1977–78. Similarly, low numbers of fires were recorded during 2002–03. However, it may be argued that 2002–03 was an exception as low fire numbers may stem from the fact that by January much of the territory fires had already burned, and possibly that the psychological impact of devastating fires may have reduced subsequent human-caused ignitions during the remainder of the season in areas that were not affected. Allowing for the exception of 2002–03, these results suggest there may well be a greater link between higher vegetation fire numbers and El Niño events in the latter part of the observation period than during the 1970s and 1980s, although more concrete data is needed before this can be established with certainty.

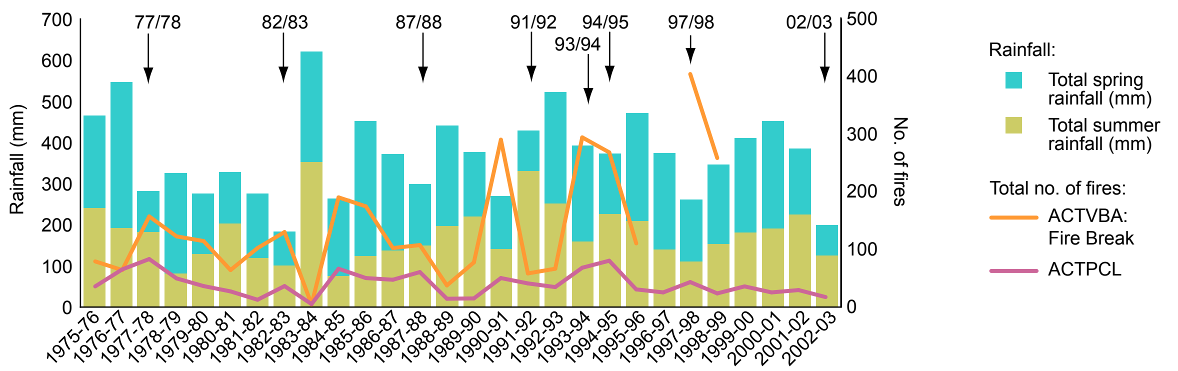
That a large number of fires did not occur during the 1991–92 El Niño event is not surprising given the low impact of this El Niño Southern Oscillation (ENSO) cycle on the territory (in terms of drought), as indicated by comparatively high summer rainfall. Conversely, high numbers of vegetation fires during 1984–85 and 1990–91, not years associated with an El Niño event, were characterised by low spring and/or summer rainfall.

Area burned: The ACTPCL and ACT Rural Fire Service (Firebreak data) recorded similar areas burned during the same years (Figure 26). This indicates that while the ACTPCL dataset only recorded a small proportion of all fires attended in rural and remote areas, that dataset does include most large fires attended in the territory over the 28-year history. As such, the ACTPCL data are broadly representative of the total area burned in the territory during this timeframe.

During this period, the two worst bushfire seasons (in terms of total area burned) occurred in 1982–83 and 2002–03, years in which the territory was gripped by drought. Both were associated with El Niño-like weather patterns (Figure 26). Large areas were not burned in years where El Niño weather patterns did not contribute to exceptionally low rainfall; not all El Niño events manifested in extreme drought conditions, and large tracts of land were not burned in the territory in those seasons.

Similarly, not all droughts or exceptionally dry conditions conducive to vegetation fires were associated with El Niño events. For example, large areas were burned in 1984–85 and in 1978–79, neither of which were associated with an El Niño event. Perhaps the distinguishing feature is that in 1982–83 and 2002–03 it was natural ignitions that gave rise to the large areas burned, whereas in 1978–79 and 1984–85 the ignitions resulting in large fires principally arose from human actions/factors. Although humans may have contributed to more fires in some El Niño years, these did not necessarily translate in greater areas burned in those years.

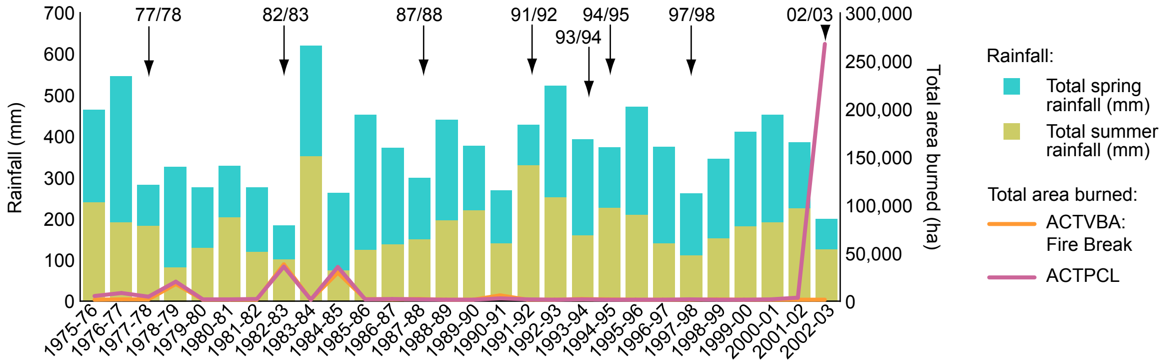
Figure 25: Number of fires (ACTPCL, ACTVBA Firebreak), and the total summer and spring rainfall, each year[a]



a: annotated numbers indicate the timing of El Niño event (Bureau of Meteorology)

Source: ACTPCL 1975–76 to 2002–03 [computer file], ACTESA 2006b, and the Australian Bureau of Meteorology [computer file]

Figure 26: Total area burned (ACTPCL, ACTESA Firebreak), and the total summer and spring rainfall, each year[a]



a: annotated numbers indicate the timing of El Niño event (Bureau of Meteorology)

Source: ACTPCL 1975–76 to 2002–03 [computer file], Firebreak, ACT Emergency Services Authority [computer file], and the Australian Bureau of Meteorology

Summary

The most important points about the ACTPCL analysis are summarised as:

- The ACTPCL database documented 988 vegetation fires from 1975–76 to 2002–03, with the total number of varying between one and 79 in any given year.
- The greatest number of vegetation fires occurred in 1977–78, 1994–95, and to a lesser extent 1976–77, 1984–85, and 1993–94; the lowest number of vegetation fires occurred in 1981–82 and 1983–84, seasons bracketing the 1982–83 drought.
- No net increase in the number of vegetation fires in territory reserves occurred through time; this is in contrast with the situation documented by the ACTVBA in Firebreak, where fire numbers climbed to 400 during 1997–98.
- 69 percent of ACTPCL fires were recorded as having been deliberately lit. On average, the proportion of deliberate fires increased from 49 percent for 1975–76 to 1984–85 to 88 percent for 1985–86 to 2002–03. This is not, however, reflected in a net increase in the number of deliberately lit ACTPCL fires; lower numbers of deliberate fires (ACTPCL only) have occurred since the mid 1990s.
- The greatest number of deliberate lightings occurred in 1994–95, followed closely by 1993–94. This coincided with an intensive period of deliberate firesetting (possibly serial arson) in the Black Mountain Reserve.
- More than three-quarters of all ACTPCL fires occurred within reserves in urban area (61%) or on the urban fringe (18%), with comparatively fewer in rural and remote locations.
- Districts that experienced the highest numbers of fires included Tuggeranong, Central Canberra, followed by Belconnen and Woden Valley Districts; serial arson appears to have been a contributing factor in both the Tuggeranong and Central Canberra areas.
- Reserves near urban developments typically experienced very high rates of deliberate fires; commonly more than 80 to 90 percent of fires were deliberately lit than were lit in more remote and rural locations.
- The majority of deliberate fires between mid December and the end of March coincide with, but also extend beyond, the peak bushfire season.

- A greater number of deliberate fires occurred on weekends than weekdays, although development of this trend varied between regions; increases in the number of fires on weekends was not observed for other causes.
- A total of 377,000 ha were burned, mostly during the 2002–03 season; 80 percent of this was burned in natural fires, principally in 1982–83 and 2002–03, two years in which the territory was badly affected by drought.
- Deliberate fires burned 11 percent of the total area. This was principally due to a number of large fires in 1984–85. The only large areas burned by deliberate fires in the territory since that time occurred in 2001–02. The number of deliberate fires or the area burned in ACTPCL did not increase during adverse seasons.
- The largest vegetation fires in the territory have originated from natural ignitions during exceptionally dry seasons associated with El Niño events. However:
  - Not all El Niño events are characterised by adverse bushfire seasons (large areas burned or significant property loss) – the impact of El Niño weather patterns on the territory are variable.
  - Adverse bushfire seasons occurred in years other than those characterised by El Niño weather patterns; human beings have contributed to the large areas burned in both 1978–79 (accidental) and 1984–85 (incendiary), but both years were characterised by unusually dry conditions.

Sources of background information

ABS 2005. *Population by age and sex, Australian Capital Territory*. ABS cat. no. 3235.8.55.001. http://www.abs.gov.au/ausstats/abs@.nsf/cat/3235.8.55.001

ABS 2006a. *Australian Capital Territory at a glance: 2006*. ABS cat. no. 1314.8. http://www.abs.gov.au/ausstats/abs@.nsf/cat/1314.8

ABS 2006b. *Australian demographic statistics*. ABS cat. no. 3101.0. http://www.abs.gov.au/ausstats/abs@.nsf/cat/3101.0

Australian Bureau of Meteorology 2007. *Average rainfall, annual: New South Wales*. http://www.bom.gov.au/cgi-bin/climate/cgi_bin_scripts/annual-monthly-rainfall.cgi

Department of Environment and Heritage 2001a. *Land use: Australian Capital Territory*. http://audit.deh.gov.au/ANRA/atlas_home.cfm

Department of Environment and Heritage 2001b. *Native vegetation types and extent: Australian Capital Territory*. http://audit.deh.gov.au/ANRA/atlas_home.cfm

Ellis S, Kanowski P & Whelan R 2004. *National Inquiry into Bushfire Mitigation and Management*. Canberra: Commonwealth of Australia. http://www.coagbushfireenquiry.gov.au/findings.htm

ACTESA 2006b. *A history of bushfires in the Australian Capital Territory*. http://www.esb.act.gov.au/firebreak/actbushfire.html

ACTESA 2006a. *ACT Emergency Services Authority annual report 2005–2006*. http://www.esa.act.gov.au/aboutus/who_we_are/annual_report/esa_annual_report_web1.pdf

Northern Territory

Contents

The first part of this chapter provides **contextual information** on the Northern Territory, including basic information about its climate, geography, land use and population. It also provides an outline of the bushfire regimes, historically important bushfire events, and overview of fire services in the Northern Territory. The second part represents an **analysis of data** provided by the Northern Territory Fire and Rescue Service. Although that agency attends many types of fire incidents, this analysis refers only to vegetation fires.

For an explanation of the key terms, limitations and methodology refer to the introduction, glossary and methodology chapters.

Introduction

The Northern Territory is a sparsely populated area of mainland Australia, located in central Northern Australia. It is bounded by Western Australia to the west, Queensland to the east, and South Australia to the south.

Geography

The territory's northern coastline is flat, consisting of low headlands mostly fringed by mangrove swamps. Darwin, the capital of the Northern Territory, lies on this coastline in the northwest corner (Figure 1). Inland is the Arnhem Land Plateau, part of a low plateau that gradually rises southward towards the town of Tennant Creek. Further south lies the rocky landscape of the Macdonnell Ranges, the highest range in the Northern Territory. This range reaches a peak of 1,511 metres at Mount Zeil, representing the highest location in the Northern Territory. Alice Springs, a major regional centre, lies on an alluvial flood plain within these ranges. Further south lays the Simpson Desert.

Major river systems south of the central plateau include the Finke and Todd rivers. North of the plateau, the Victoria and Daly rivers drain to the Timor Sea, the Adelaide, Mary and South and East Alligator rivers drain to the Van Diemen Gulf, and the Roper and McArthur rivers flow east into the Gulf of Carpentaria.

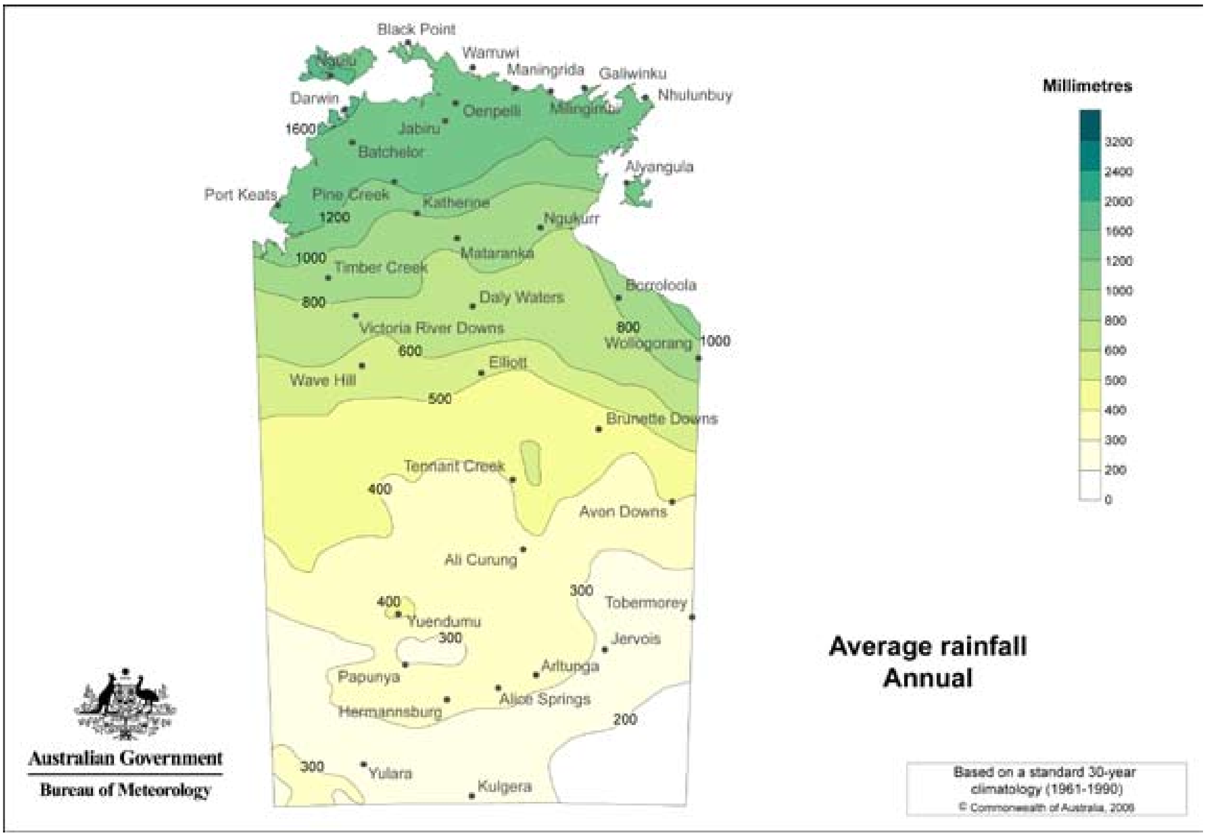
Figure 1: Map of the Northern Territory

Climate

The Northern Territory has two seasons, a dry warm season and a wet hot season, that occur in response to the movements of the equatorial lows between the northern and southern hemispheres. The wet season spans November to April. The arrival of the lows brings monsoonal rains that dominate the summer months, and lead vegetation, particularly grasses and herbs, to flourish. These monsoonal effects are most prominent closest to the northern coast, with both the total amount and predictability of rainfall tending to decrease further south.

A sharp decline in humidity and surface soil moisture content occurs with the rapid arrival of the dry season. Continued dry conditions over subsequent months leads to curing of grasses and other vegetation, and the land becomes primed for fire activity. Average annual rainfall decreases markedly away from the coastal strip, where the annual rainfall is greater than 1,200 mm, to less than 200 mm in the Simpson Desert, in the southeast corner of the territory (Figure 2). The north of the state is prone to exceptionally hot and humid conditions for eight months of the year, and may experience tropical cyclones during the wet season. Conditions in the south are commonly hot but drier, and much of the desert can experience cold nights during winter (Australian Bureau of Meteorology 2007a,b).

Figure 2: Average annual rainfall



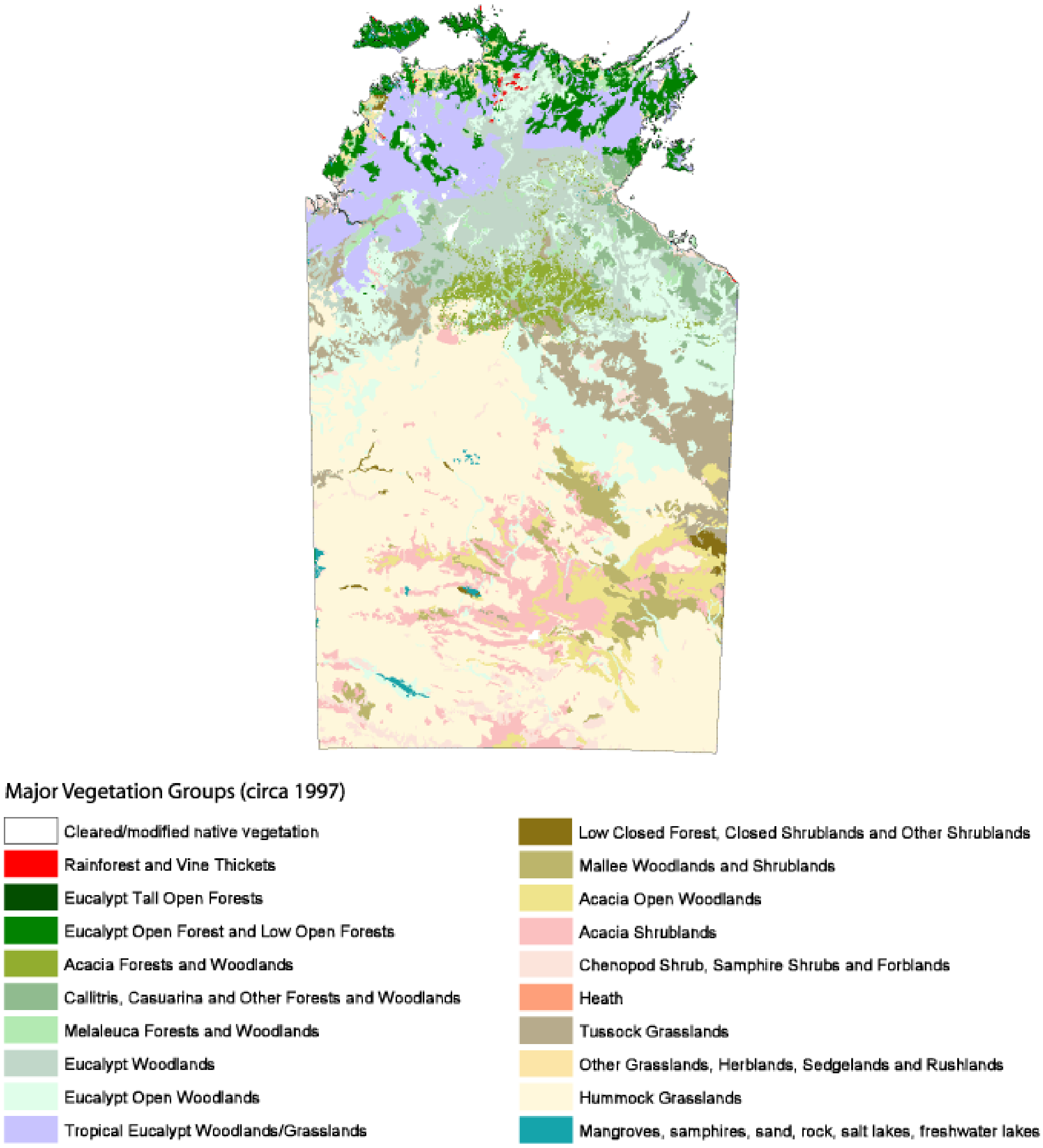
Source: Australian Bureau of Meteorology 2007b

Native vegetation

Changes in climate (from wet tropical in the north to arid in the south), landscape, and soils contribute to marked diversity in native vegetation across the territory. In the north the vegetation is typically tropical savanna (eucalypt woodland and eucalypt open woodland with a grassy understorey; Figure 3). Intense growth occurs during the wet season (summer). This landscape becomes quickly desiccated during the dry season, being subject to widespread fire activity. Unique tropical wetlands occur in the north (for example Kakadu National Park), being an important breeding area, habitat and refuge for a wide variety of species.

To the south, eucalypt woodlands transition into areas of melaleuca and acacia forests and woodlands, and further south into spinifex (hummock grasslands), mitchell grass (tussock grasslands) and acacia woodlands and shrublands. Around Alice Springs areas of mulga, mallee, chenopods, hummock grasslands, small pockets of eucalypt woodlands and salt lakes mark increased biodiversity (Australia. Department of Environment and Heritage 2001b).

Figure 3: Major vegetation groups (c. 1997)

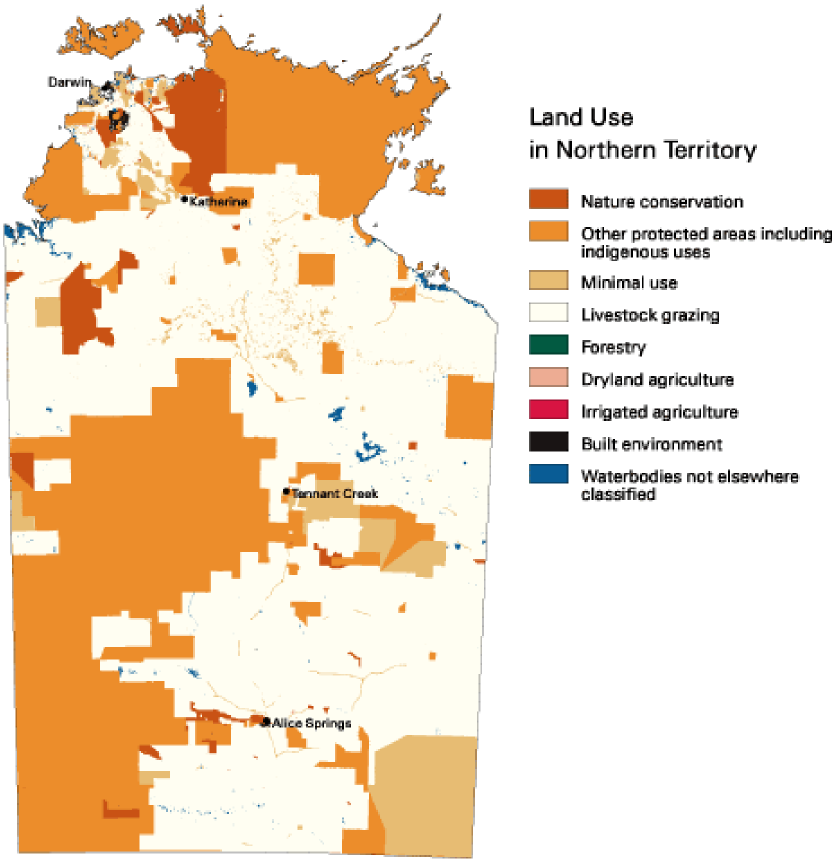


Source: Australia. Department of Environment and Heritage 2001b

Land use

Major land uses in the Northern Territory are livestock grazing and protected areas including Indigenous uses (Figure 4); as of 1996–97, these uses constituted 53 percent (71 million hectares) and 36 percent (48 million hectares) of the territory respectively. The principal industries are beef cattle and tropical fruit (mangoes and bananas). Approximately four percent of the state is used for nature conservation, of which national parks are the principal component. Kakadu National Park in the north and Uluru–Kata Tjuta National Park in the south are managed jointly by the federal government and their Aboriginal custodians (Australian Department of Environment 2001a).

Figure 4: Land use (c. 1996–97)



Source: Australia. Department of Environment and Heritage 2001a

Population

As of June 2006, the resident population of the Northern Territory was 206,700, comprising 1.0 percent of Australia's population (ABS 2006). The majority of people live in the three major urban areas of Darwin, Alice Springs and Palmerston. A further 7.8 percent of the territory's population lives in Katherine, Nhulunbuy and Tennant Creek. As of 30 June 2001, approximately 13 percent of Australia's Indigenous people lived in the Northern Territory, with more than one in four (29%) in the territory being of Indigenous origin.

As of 30 June 2005, the median age for the Northern Territory was 30.9 years; somewhat lower than the national average of 36.6 years. Children younger than 15 years comprised one-quarter (24.9%) of the Northern Territory population at 30 June 2005, the highest of any jurisdiction in Australia (ABS 2005a).

Bushfire regimes

This discussion of the bushfire regimes in the Northern Territory is restricted to the burning practices that dominate the tropical savannas, including not only the Top End (Northern Territory), but also the Kimberley (Western Australia) and Cape York (Queensland). Information has been sourced from Dyer et al. (2001), North Australia Fire Information (2007) and the Northern Territory Department of Natural Resources, Environment and the Arts (NRETA 2006a).

Few people are aware of the role, the process or the scale of burning (controlled and uncontrolled) that occurs in the tropical savannas of northern Australia. Bushfires are a ubiquitous feature of the Northern Territory dry season, with the territory having the most frequent, largest and more poorly documented vegetation fires of any part of the continent. When considering Northern Territory bushfires it is necessary to discard all preconceptions of size, frequency and even harm, based on southern vegetation fire regimes, as they are simply not translatable to the savannas that dominate Australia's north.

Bushfire regimes (that is, intensity, size, patchiness, timing etc.) in the Northern Territory are intimately related to the territory's unique (with respect to southern Australia) climate. Climate determines the timing and distribution of rainfall, but also commensurately the type and distribution of the vegetation, and the human occupants, whose fire management practices vary with their intended land use goals (for example, fuel reduction versus weed management).

Bushfire danger season: Bushfires occur during the dry season from March to December. The timing is dependent on the weather, fuel availability and the cause and probability of ignition; other factors govern how far and fast fires travel through the landscape. Ultimately, people play a pivotal role in fire activities in the tropical savannas. They are responsible for lighting the majority of vegetation fires, either accidentally or intentionally, may actively suppress fires in certain regions and, through land use, determine fuel loads and hence likelihood of occurrence and extent of bushfires.

Land management: Bushfires in the northern savannas reflect both natural and human influences. With regard to the latter, fire forms an essential component of both traditional and other land management practices. Vast tracts of land are burned across the territory every year by many different groups of people including:

- **Pastoralists**: The Northern Territory, Western Australia and northern Queensland contain large cattle stations that range in size from 300 to 12,000 square km. Burning is used to prevent wildfires, improve pasture, manage grazing, control weeds and enhance biodiversity. Fires are commonly suppressed in fire-prone areas to protect valuable grass resources for livestock.
- **Aboriginals**: Indigenous people have used burning practices for thousands of years to aid in hunting, communication, horticulture, ease of travel, and protection of sacred sites, serving social, cultural, spiritual as well as ecological needs.
- **Conservationists**: Northern Australia contains biodiverse habitats of world environmental significance. Fire management plays a significant role in managing the biodiversity of these lands.
- **Tourism operators**: Attraction to the unique nature of the territory, Kimberley and Cape York environments provides a flourishing tourism industry. Burning plays a significant role in managing major national parks and other attractions, including maintaining the biodiversity in these regions. A lack of understanding about the nature of fire activity in maintaining the savannas potentially leads to conflict over environmental management practices.
- **Defence personnel**: The federal Department of Defence has substantial holdings in the territory. Fire management of these lands is essential, particularly as the land is unstocked and therefore prone to high fuel loads building up. Fire risk is increased by use of incendiary devices.
- **Mining operators**: Although mining holdings are small, fire management is a significant component of both exploration and rehabilitation.

The timing and nature of controlled burning may vary between each of these groups depending not only on the goal (such as, fuel-reduction, weed control, access, hunting, maintaining biodiversity), but also on the climatic and environmental regime in which they are located. For example, in Kakadu, traditional Aboriginal burning typically began late in the wet season (March) and continued for nine to 10 months, with activity peaking in June–July, and relatively little burning occurred in August–September. Although often opportunistic (for example, a person 'happened' to be in the area), traditional burning practices are complex and are conducted on a patchwork basis at specific times, to minimise escape and damage, and to prevent wildfires. Many fire agencies across the territory are now endeavouring to employ traditional burning practices, as this type of burning is less intense, and maintains more diverse habitats than do large hot fires.

Collectively, the majority of controlled burns occur early in the dry season, yielding a patchwork of burned and unburned country to minimise the risk of widespread intensive fires later in the dry season, or to yield a 'green pick' for livestock. Limited late dry season burning is used in some environment management practices. A failure to undertake fire management may result in infestations of non-native weeds and pastures, and a dangerous build-up of fuel reserves that are subsequently susceptible to burning by natural, accidental and deliberate fires. Large-scale natural fires typically occur late in the dry season, and are considered undesirable as they are commonly intense (hot), extensive, and likely to be more detrimental to flora and fauna.

Area burned: The frequency and area burned in any one year varies considerably. Nevertheless, by southern standards the total and the proportion of land burned in any given year is extraordinarily large. In the higher rainfall savanna woodlands of the northern Kimberley, the Top End and Cape York up to half of the total area may be burned either every year or every second year (Anderson 1996, Dyer et al. 2001, Press 1998, Russell-Smith et al. 1997). Many of these fires are intense and therefore pose the most danger in terms of their capacity to devastate populations of fire-sensitive native plants and animals, to be costly and disruptive to pastoral operations, and to pose a threat to communities and property. The frequency of fires tends to decrease further south for a number of reasons. They include reduced rainfall and therefore vegetation density, reduced grass reserves due to intensive use of these savannas for grazing, and greater efforts to suppress fires to prevent destruction of valuable fodder resources.

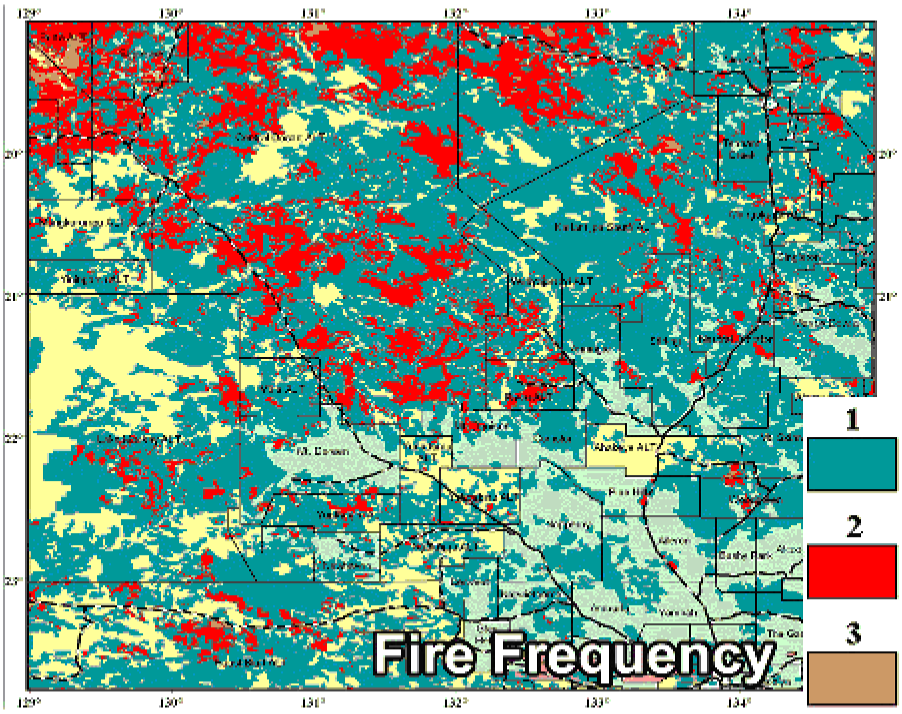
Although this discussion has focused on the savannas, many of the territory's desert regions are also subject to significant burning (NRETA 2006a). Figure 5 illustrates the total area burned in desert regions between May 1999 and April 2004 for a tract of land to the west and southwest of Tennant Creek. The majority of this land has been burned at least once in this five-year period, with progressively smaller areas having been burned two or three times.

Intense fires commonly started by lightning strikes during particularly dry seasons have occurred throughout the Northern Territory's modern history. The amounts of land burned in these events are extraordinary. The Council of Australian Governments report (Ellis, Kanowski & Whelan 2004) lists four major bushfire seasons in the territory since the late 1960s that collectively burned 168,000,000 ha. In 2002, approximately 38,000,000 ha burned in planned and unplanned fires. This represents 29 percent of the Northern Territory. In comparison, the January 2003 fires burned 'only' 226,000 ha in the Australian Capital Territory and 1,000,000 ha in Victoria.

Changes in fire regimes: Fire regimes have changed substantially since European occupation, with changes in land use and the nature and extent of fire management strategies. Active suppression of fires in semi-arid areas to prevent loss of highly valuable grass for livestock affects species that require fire to propagate or regenerate. It also appears that the frequency of intense, late dry season fires has increased in the wetter northern regions. These fires pose the greatest danger to the survival of fire sensitive flora and to fauna, and therefore to biodiversity in general. Furthermore, current fire regimes employed on traditional lands may differ from past traditional practices as people are no longer dispersed through the country and traditional knowledge has either been lost or has not been passed on to the current generation.

Changes in previously established patterns, whether through land management or, most pertinent to this discussion, the activity of arsonists can induce major environmental changes and loss of biodiversity. Intense fires are particularly damaging, resulting in a significant decrease in abundance and diversity across most faunal species.

Figure 5: Desert fires in central Australia, May 1999 to April 2004



Source: NRETA 2006b

Bushfire history

Given the exceptionally large areas burned every year, and the comparatively recent timeframe over which these have been documented in detail, accurately documenting historical variations in the total area burned is somewhat problematic. Ellis and colleagues (2004) document four years (1968–69, 1969–70, 1974–75 and 2002) in which particularly large areas (approximately 40,000,000 ha) were burned (Table 1).

Table 1: Fire history of the Northern Territory

Date	Area of fire (ha)	Location(s)
1968–1969	40,000,000	Killarney–Top Springs
1969–1970	45,000,000	Dry River–Victoria River fire
1974–1975	45,000,000	Barkly Tableland, Victoria River district, near Newcastle Waters
2002	38,000,000	

Source: Ellis, Kanowski & Whelan 2004

Fire services

Fire services in the Northern Territory include the Bushfires Council of the Northern Territory and the Northern Territory Fire and Rescue Service.

Fire management, in relation to land use planning and control functions outside major urban centres, is governed by the **Bushfires Council of the Northern Territory**, a statutory body established by the *Bushfires Act*, that is organisationally part of the territory's Department of Natural Resources, Environment and the Arts. Under the Act landowners in non-urban areas are able to burn their land except on fire ban days, in fire protection zones, and in fire danger areas. With the possible exception of some traditional burning practices, which may receive legal protection under various aspects of commonwealth, territory and common law (see for example, Hughes 1994), fires by non-landholders, or fires lit by landholders on fire ban days, in protected zones or fire danger areas are illegal. More information about the Bushfires Council of the Northern Territory can be found at: http://www.nt.gov.au/nreta/naturalresources/bushfires.

Fires in urban areas are the responsibility of the **Northern Territory Fire and Rescue Service** (NTFRS), which was established under the *Fire Service Act 1983* (NT), and forms part of the Northern Territory Police, Fire and Emergency Services. The NTFRS incorporates ten stations based at Alice Springs, Casuarina, Darwin, Humpty Doo, Jabiru, Katherine, Nhulunbuy, Palmerston, Tennant Creek and Yulara. In addition, volunteer units are based throughout the state. The NTFRS incorporates 165 permanent, 54 paid auxiliary and 250 volunteer firefighters. Five volunteer brigades are located in the Darwin area, with further units stationed throughout the territory. These agencies are responsible for issuing permits to burn. Generally, permits are available from December to May depending on the prevailing weather conditions although permits are required all year round north of Katherine and no permits are allowed within the municipal boundaries of Darwin or Palmerston (NTFRS 2006).

The analysis undertaken in this report is based on data obtained from the NTFRS and includes all vegetation fires this service has documented for the period July 1999 to November 2004. It is necessarily dominated by vegetation fires that occurred in urban or semi-urban areas that fall within the jurisdiction of NTFRS stations; it does not include vegetation fires that volunteers attended in more remote areas of the territory. With the exception of the occasional fires the NTFRS attended, this report does not provide analysis of the frequency, total area burned or extent of illegal fire practices in more regional and remote areas of the territory; and the extent of incendiary and suspicious fires within the savannas and desert country remains largely unknown. Nevertheless, illegal and unnecessary fires have historically contributed to large areas burned in the tropical savannas. The Northern Territory Minister for Lands and Planning indicated that although lightning strikes and land management activities played a part in the 38.4 million ha burned in the territory in 2002, many fires were either deliberately lit or were due to careless actions of people travelling through the territory (Ellis, Kanowski & Whelan 2004).

Northern Territory Fire and Rescue Service analysis

Background about the NTFRS dataset and its analysis

Important information about the NTFRS dataset and the methodology employed to analyse it is summarised as:

- The data were sourced from Northern Territory Fire and Rescue Service (NTFRS).
- The dataset provided only included vegetation (AIRS wildfires) fires. Hence, all references to fires in this analysis refer to vegetation fires only. References to all fires and total fire frequencies refer to all vegetation fires irrespective of cause.
- The fires documented occurred from 1999–2000 to November 2004.
- Fires within the database used AIRS variables, categories and codes.
- The cause of fires, defined for this analysis, is based on the ignition factor variable.
- Deliberate fires include all fires classified as incendiary (AIRS ignition factor code = 110 or 120) or suspicious (AIRS ignition factor code = 210 or 220) within the ignition factor variable.

- Natural fires include all fires where the ignition factor codes were 800 to 890, that is fires resulting from any natural condition or event. The breakdown of specific causes within this variable included high wind, 33 percent; lightning, 41 percent; and any other natural condition (not classified or having insufficient information to classify further), 26 percent.
- The dataset included information about the form of heat of ignition.
- Smoking-related fires were classified on the basis of:
- Form of heat of ignition = 'Heat from smokers' materials' (AIRS codes 300 to 390).
- The causal classification of smoking-related fires was 56 percent accidental, 1.7 percent incendiary, 29 percent suspicious and 12 percent unknown.
- All fires attributed to children, and discussed in the text, were non-deliberate and were classified as accidental in origin. Deliberate fires started by children were classified as incendiary or possibly suspicious and hence cannot be delineated from other fires within these categories. Some information about the age of children was supplied but was incomplete.
- Regions used in analysing territory fires were based on Australian Bureau of Statistics (2005b) tourism regions. Fires were assigned to region using the suburb name provided. There was not an exact concordance between the suburb and tourism regions. The latter were defined based on statistical areas and may crosscut suburbs (although this was unlikely in the Northern Territory). In this study, assignation was based on the highest levels of concordance. Note that, although the term region is used, the data refer to vegetation fires that occur in major urban centres located within those regions.
- Unlike other jurisdictions, the NTFRS analysis uses calendar not financial years, so as not to split what is a contiguous bushfire season over two successive years.
- The dataset provided included data about the area burned.
- No information was available about fire restrictions or fire danger index.

For more detail about these methodologies see the methodology chapter.

Two significant factors that impinge upon the data may not be experienced, at least to the same degree, by other urban-based agencies in Australia. The factors are:

- The large fires that occur throughout the tropical savannas, whether originating from natural causes, land management activities, or traditional practices, may encroach on urban communities and hence be attended by the NTFRS. The inclusion of these large-scale fires has a marked impact on the total area burned in any year, but does not necessarily bare any relationship to the total area burned in any one year across the territory or the severity of the bushfire season in general.
- Differences in cultural practices. Fire is central to Indigenous Australian's way of life, having been used to clear a camp, hunt, cook, and keep warm for thousands of years. Such practices that may be commonplace in regional and remote communities are commonly maintained when Indigenous Australian migrate into urban areas that fall under NTFRS jurisdiction. This necessarily impacts on the incidence and spatial and temporal distribution of fires documented in these areas. Cultural differences in the way these fires are perceived may influence the causal attributions made. For example, it is possible that some fires within the database may have been classified as deliberate (incendiary or suspicious), that would not be perceived as such by Indigenous people.

Overview

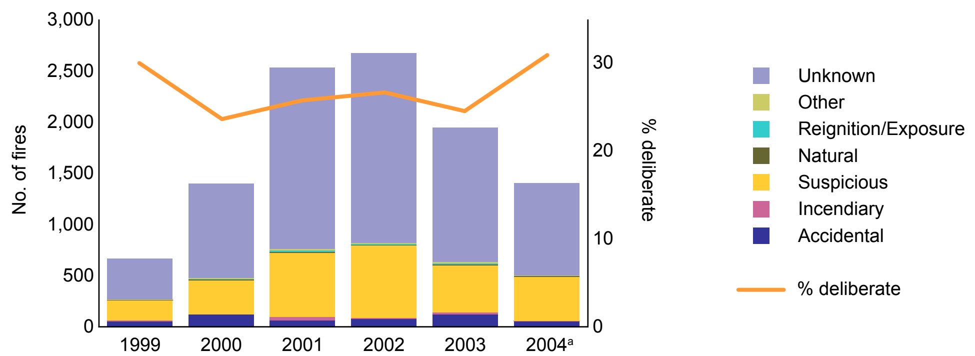
Fires the NTFRS attended in the review period are summarised as follows:

- 10,650 vegetation fires from July 1999 to November 2004. The greatest number occurred in 2001 and 2002, when 2,538 and 2,681 fires were attended respectively (Figure 6).
- The fires primarily consisted of grass fires (47%), small vegetation fires (36%) and mixed scrub/bush/grass fires (15%). The relative proportions of vegetation types varied between urban centres.
- 27 percent of fires were deliberate, but the cause of 67 percent of fires was unknown. Hence, deliberate causes accounted for 81 percent of all cases where a cause was delineated. The proportion of unknown causes varied markedly between centres, hampering attempts to delineate regional differences in the extent of deliberate fire setting or to establish a definitive estimate of the rate in urban centres territory-wide.
- Approximately 1,068,870 ha were burned in the vegetation fires the NTFRS documented. This does not accurately reflect the total amount of area burned in the territory during the same interval. The temporal variations in the area burned do not necessarily reflect the severity of the bushfire season during that time.
- The timing of fires varied markedly between urban centres, most likely reflecting both environmental and social factors.

Cause

The cause of about two-thirds of NTFRS vegetation fires attended was unknown (Figure 7). Accidental causes were assigned definitively in 3.5 percent of cases, other causes to 2.8 percent of fires, and incendiary fires to 0.7 percent of fires. However, incendiarism was suspected in further 25.8 percent of cases, making it the single largest 'known' causal category. Combined deliberate causes (suspected and incendiary fires combined) accounted for 26.5 percent of all NTFRS attended vegetation fires, and accounted for 81 percent of all vegetation fires where a cause was allocated. The percentage of deliberate vegetation fires remained comparatively uniform throughout the review period, ranging from 24 to 31 percent in any given year.

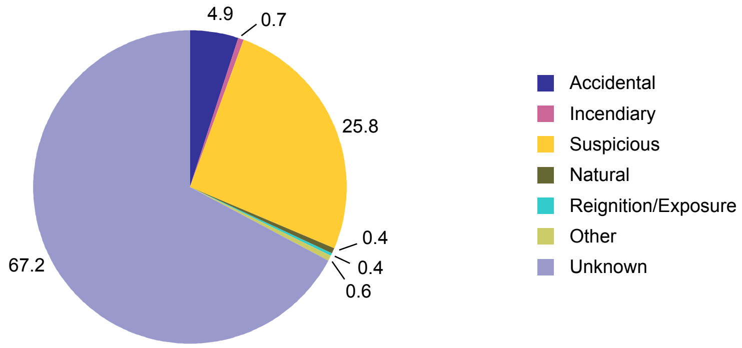
Figure 6: Cause of fires each year (number)



a: data for 1999 and 2004, in this and all subsequent figures, was based on six and 11 months of data respectively

Source: NTFRS 1999–2000 to November 2004 [computer file]

Figure 7: Cause of fires (percent)

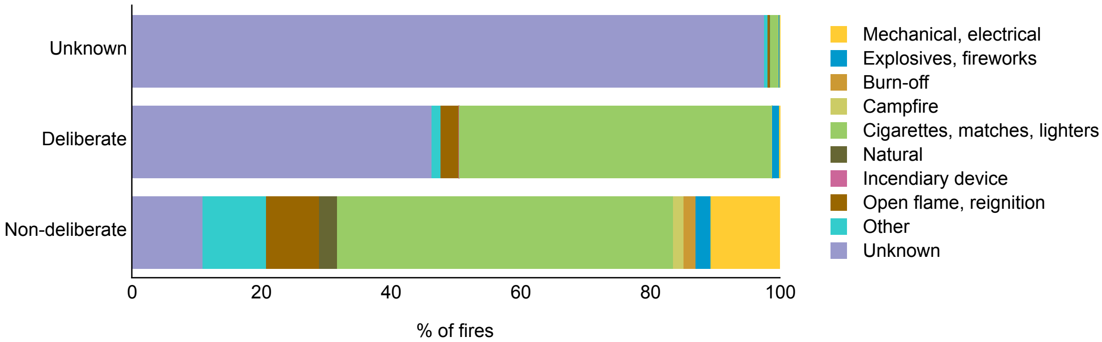


Source: NTFRS 1999–2000 to November 2004 [computer file]

Specific ignition factors

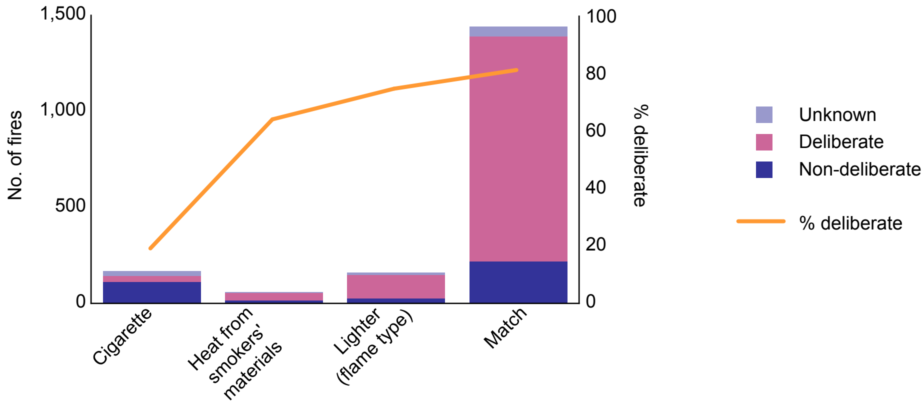
The **form of heat of ignition** was unknown in 80 percent of vegetation fires (irrespective of cause) although the form of heat ignition was known for a greater proportion of non-deliberate, as compared to deliberate, fires (Figure 8). Of the roughly 20 percent where the form of heat of ignition was assigned, the overwhelming majority fell within the category of 'cigarettes, matches and lighters'; of these, matches were the highest contributor (Figure 9). Approximately 70 to 80 percent of all vegetation fires started by matches and lighters were deliberately lit. Comparatively few vegetation fires in urban areas of the territory resulted from mechanical or electrical failure, or other accidental causes. An incendiary device was only documented in one case.

Figure 8: Cause of fires, by form of heat of ignition (percent)



Source: NTFRS 1999–2000 to November 2004 [computer file]

Figure 9: Specific forms of heat of ignition, for fires within the 'smoking-related materials, lighters and matches' category, by cause

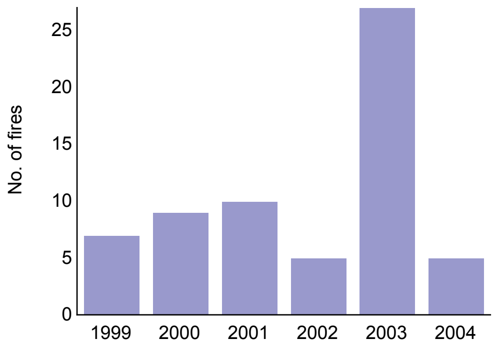


Source: NTFRS 1999–2000 to November 2004 [computer file]

Children less than 16 years old were implicated in accidentally (resulting from play) starting 63 vegetation fires (0.6% of all vegetation fires) in the territory between July 1999 and November 2004. This is unlikely to be an accurate reflection of the number of fires children started. Notably, if the intent was deemed malicious, fires started by children were classified as incendiary or suspicious within the ignition factor; that is, they were not delineated as a separate variable. The comparatively low number of child vegetation fires also reflects the fact that this classification requires physical evidence that a child was involved; for example, the child was seen at the location of fire at the time it started. Moreover, the cause of the vast majority of fires was unknown. Accidental child fires comprised 1.8 percent of causes were a cause was assigned in the ignition factor variable.

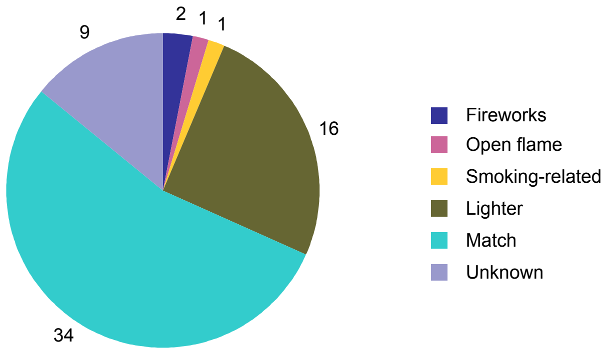
Typically, less than ten non-deliberate child fires occurred in any one year (Figure 10). The exception was 2003 when 27 vegetation fires were identified. The form of heat of ignition in the majority of cases was matches or lighters, with only one vegetation fire having been smoking-related (Figure 11).

Figure 10: Non-deliberate child fires, by year (number)



Source: NTFRS 1999–2000 to November 2004 [computer file]

Figure 11: Non-deliberate child fires, by form of heat of ignition (number)



Source: NTFRS 1999–2000 to November 2004 [computer file]

Smoking-related materials accounted for less than three percent of fires the NTFRS attended annually. The majority of smoking-related fires were classified as accidental (non-deliberate), although owing to the classification system adopted (see Methodology), a small proportion also lie within the deliberate (31%) and unknown categories (12%; Figure 9).

Location

This section examines the regional distribution of fires and the incidence of fires in those regions relative to the population densities.

Region

Fires were assigned to one of nine ABS (2005b) tourism regions (Figure 12; see also Methodology section). Thirty-eight percent of vegetation fires the NTFRS attended occurred in the Darwin region, 29 percent in the Alice Springs region, 17 percent in the Katherine region, and six percent in the Tablelands region (Figure 13).

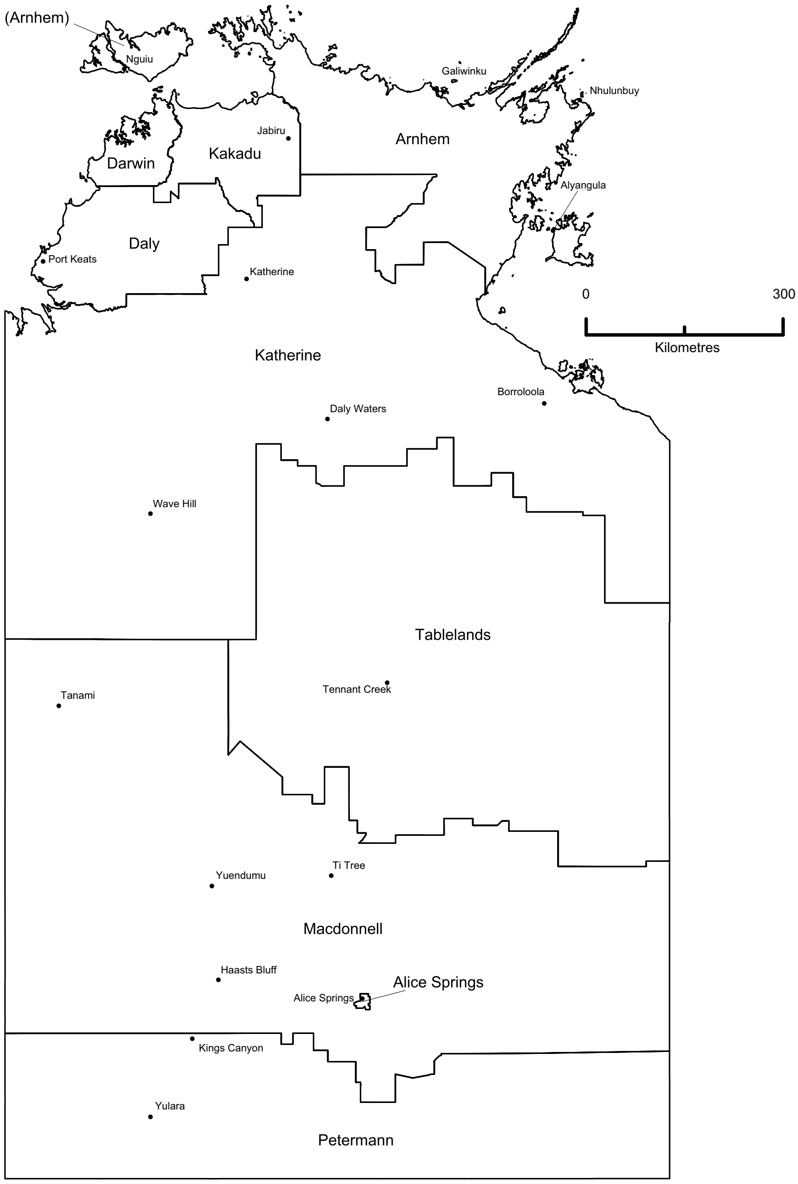
The proportion of vegetation fires identified as deliberate varied markedly between regions. The highest recorded rates occurred in the Tablelands region (70%), followed by Alice Springs (42%), Petermann and Kakadu (26%; Figure 14). The proportion of deliberate fires in Darwin was 19 percent. However, assignment of cause varied substantially between regions, with the proportion of causal attributions being highest in the Alice Springs and Tablelands regions but very low in Katherine, Kakadu and to a lesser extent Darwin. Based on the relative proportions of non-deliberate and deliberate fires already identified, it is possible that between 40 and 94 percent of vegetation fires in individual regions of the territory were deliberately lit. However, such estimates are inherently inaccurate given the low level of causal attributions in most cases. Overall, sixty-five percent of ‘known’ attributions in the Darwin region were classified as deliberate. Although high this was within the range observed across agencies and jurisdictions nationally.

The number of fires in **Darwin** each year remained relatively uniform, varying between a low of 630 in 2000 and a high of 932 in 2001 (Figure 15). Thirty-five suburbs in the Darwin region observed more than 50 vegetation fires in approximately 5.5 years; eleven recorded more than 100 fires over the same interval. Berrimah and Howard Springs, each recorded approximately 250 fires in total. Despite the large range in fire frequencies, the proportion of deliberate fires was comparatively uniform across those suburbs recording more than 100 fires over the observation period (Figure 16).

The number of fires in Alice Springs region was highly variable ranging between 266 in 2000 and 1,221 in 2002 (Figure 15). Although the number of fires in Alice Springs may be impacted the low and more erratic rainfall (Figure 2), social factors were likely to be the largest contributor to large variations in fire incidents. A similar trend was evident for the Petermann region (Figure 17), albeit at markedly lower frequencies. Vegetation fires in the Tablelands and Katherine regions occurred in or near the major urban centres of Tennant Creek and Katherine respectively. The total number of fires in the Tablelands region varied between 84 and 231 per year. The number of fires in Katherine was slightly more stable ranging between a low of 210 in 2004 (11 months only) and a high of 409 in 2002. Vegetation fires in Arnhem and Kakadu principally occurred near the mining towns of Nhulunbuy and Jabiru, respectively.

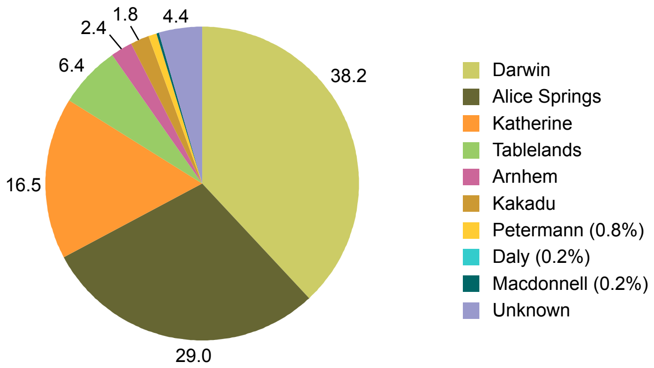
Approximately, three-quarters of accidental fires lit by children occurred in the Darwin region (Figure 18). The highest number of such incidents – four to six fires in 5.5 years – occurred at Knuckey Lagoon, Alice Springs, Moulden, and Tennant Creek.

Figure 12: Tourism regions of the Northern Territory



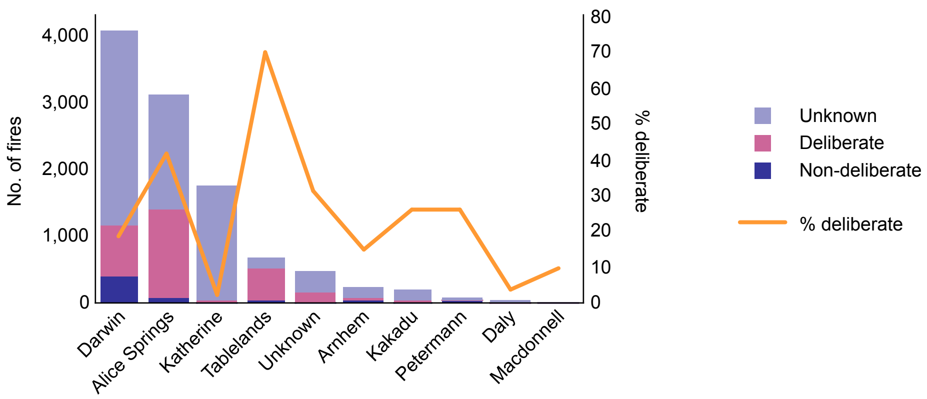
Source: ABS 2005b

Figure 13: Region (percent)



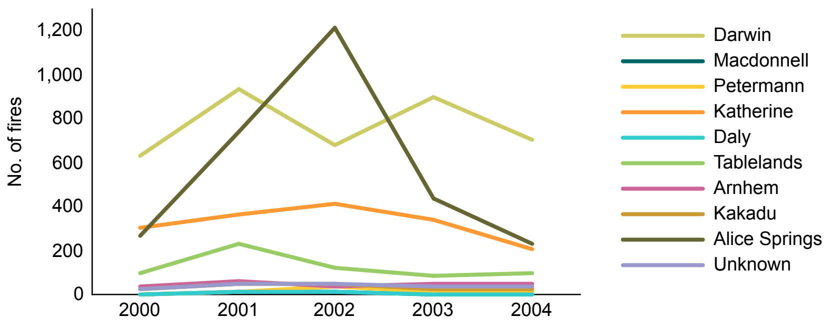
Source: NTFRS 1999–2000 to November 2004 [computer file]

Figure 14: Cause of fires, by region



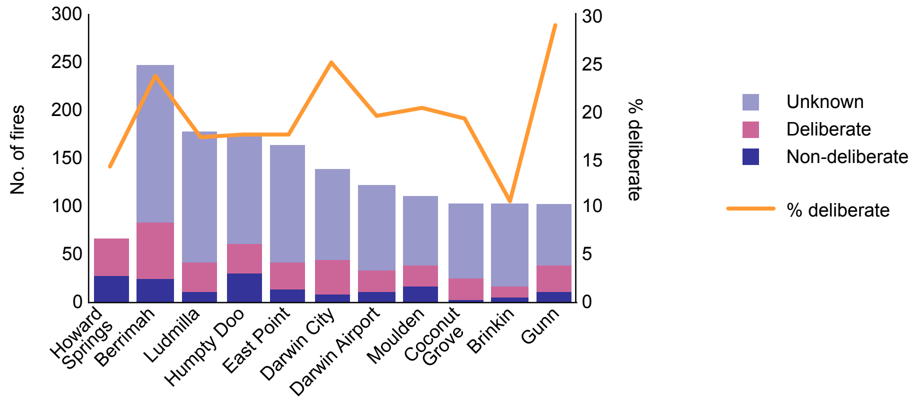
Source: NTFRS 1999–2000 to November 2004 [computer file]

Figure 15: Yearly variation in the number of fires in each region (number)



Source: NTFRS 1999–2000 to November 2004 [computer file]

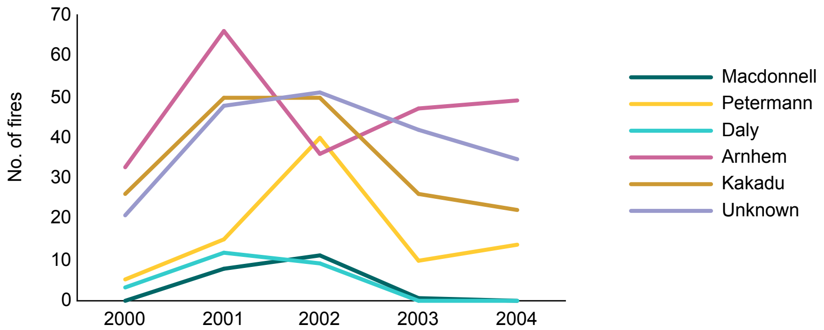
Figure 16: Cause of fires by suburb[a], for Darwin region



a: only includes suburbs that recorded in excess of 100 fires in the observation period

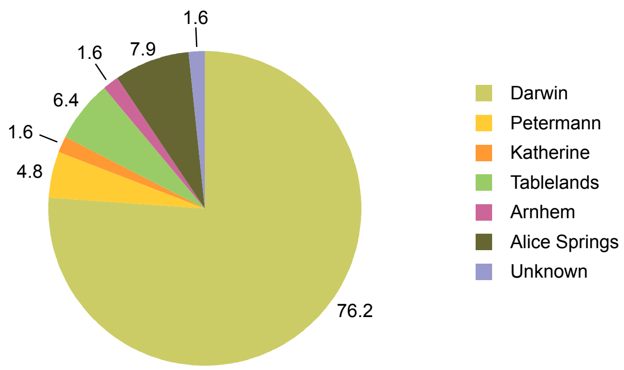
Source: NTFRS 1999–2000 to November 2004 [computer file]

Figure 17: Yearly variation in the number of fires for selected regions (number)



Source: NTFRS 1999–2000 to November 2004 [computer file]

Figure 18: Non-deliberate child-fires by region (percent)



Source: NTFRS 1999–2000 to November 2004 [computer file]

Population analysis

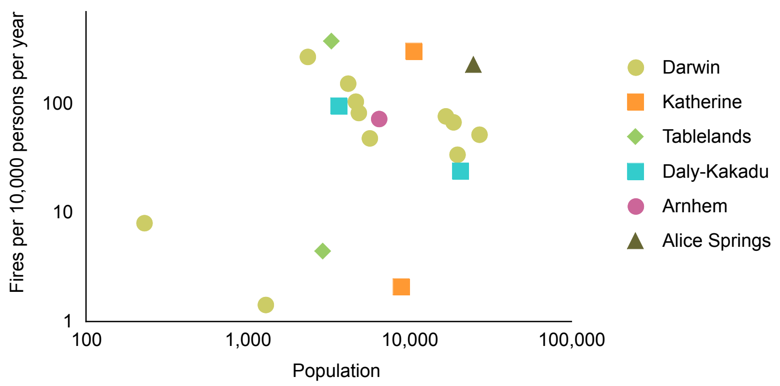
All vegetation fires: The highest numbers of fires were associated with the largest urban centres, namely Darwin and Alice Springs. Nevertheless, there was poor correspondence between the total fire frequencies and population at a postcode level ($r = .56$). This may reflect the inherent difficulties of analysing urban fire statistics on a per person basis in the Northern Territory. The fire data only pertains to urban areas, but individual postcodes are geographically large, with fewer than 30 postcodes covering the entire Northern Territory, and many of those lie within the Darwin region. While postcodes in the Darwin region may be largely urban, postcodes in regional areas incorporate urban, rural and remote localities, each with very different population densities and inherent bushfire regimes. This may lead to limited correlation between the areas covered by each postcode and the jurisdiction of the NTFRS and there can be poor correlation between postcodes and regions (based on the ABS tourism region; see Methodology). Nevertheless, urban centres do account for the dominant proportion of the population within each postcode, and it is these centres to which the NTFRS data pertains.

The calculated number of fires per person per year for individual postcodes within the territory was among the most variable observed in any state or territory in Australia; varying between one and 380 fires per 10,000 people per year (Figure 19). Four postcodes were characterised by very low frequencies of fires relative to their population size; they were 0862, 0852, 0837 and 0846. High numbers of fires per person – relative to other postcodes with a similar population – occurred in four suburbs; 0860 (Tablelands), 0850 (Katherine), 0870 (Alice Springs), and 0828 (Darwin). Generally, the rates per person were equivalent to or marginally higher than the highest values observed for other jurisdictions.

Deliberate vegetation fires: The data indicate that between three and 260 deliberate fires per 10,000 people per year in individual postcodes were lit (Figure 20). The highest rates, 260 and 100 deliberate fires per 10,000 people, were recorded in the 0860 (Tablelands) and 0870 (Alice Springs) postcodes respectively. However, it is also necessary to take into account that the rates of 'known' attributions were generally higher (72% and 45% respectively) in these areas than in most Darwin postcodes where the cause of 20 to 40 percent was assigned for individual postcodes. The rate of deliberate fires per person per year observed in 0860 and 0870 were comparable to the highest rates observed in other jurisdictions, for postcodes with an equivalent population.

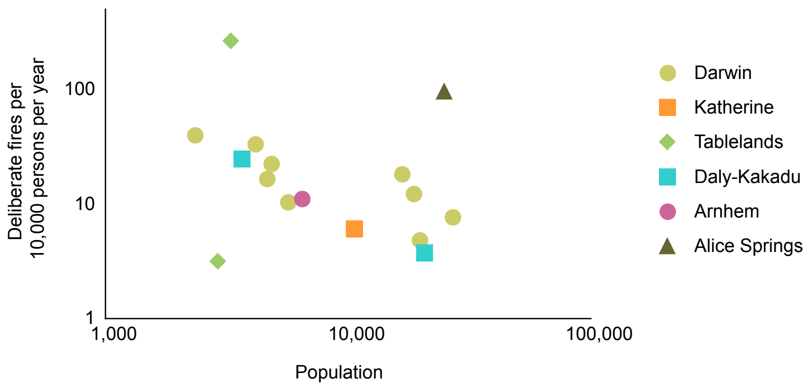
Comment: The territory was unique in that the highest frequencies of fires and deliberate fires per person occurred for regional rather than metropolitan postcodes. There were two possible contributing factors. One potentially relates to population distributions; the higher fire frequencies per person may partially manifest as a result of the lower levels of urbanisation in the territory. Notably, the proportion of the population in the territory living in an urban area is 73 percent. This compares to 80 to 90 percent in most other states, except Tasmania, where the levels of urbanisation are similar. In other states, except Western Australia, there was tendency for total vegetation fire frequencies per person to extend to higher levels in areas of lower urbanisation. The second and possibly more important factor, which is not of significance to many other parts of the country, probably relates to different cultural practices that take place in the territory. The continuance of traditional fire practices by Indigenous people moving from remote areas to urban centres necessarily impacts on the total fire frequencies observed in those centres. On a relative basis, this was of greater importance for smaller regional centres than it was for Darwin, and necessarily impacts on the total fire frequencies recorded for Alice Springs, Katherine and other regional centres. In instances where there may have been differences in the cultural perceptions of fire, there will inevitably be a flow-on effect for the number of recorded deliberate fires. Active efforts have been introduced to take these cultural differences into account (see below), and this will affect subsequent fire statistics.

Figure 19: Relationship between total fire frequency and population in individual postcodes (number)



Source: NTFRS 1999–2000 to November 2004 [computer file]; ABS 2004. Population by post office area, 2001 [computer file]

Figure 20: Relationship between deliberate fire frequency and population in individual postcodes (number)



Source: NTFRS 1999–2000 to November 2004 [computer file]; ABS 2004. Population by post office area, 2001 [computer file]

Timing

The timing of fires is examined by week of the year, day of the week and time of the day.

Week of the year

Overall, fire frequency increased sharply in early to mid March and remained high until mid October, before again decreasing rapidly, as the wet season arrived. This trend was present irrespective of the cause of the fire (Figure 21).

The week of the year that NTFRS-attended fires most commonly occurred varied from year to year, both in terms of the peak intensity, the length of time for which peak intensities were maintained, and the timing at which fire frequencies increased and decreased. Higher frequencies consistently occurred between May and mid October, but considerable variations were evident in fire frequencies in March and April (Figure 22). The bushfire season in 2000 in the territory started comparatively later (approximately week 20), whereas in 2001 and 2003 substantial increases in fire frequency occurred in week 15. In the devastating year of 2002, fire numbers increased sharply in February and had peaked by week 12 to 13. The timing of the cessation of the bushfire season was more consistent across seasons. That is, the beginning of the wet arrived more consistently than the beginning of the dry season, at least in some parts of the territory.

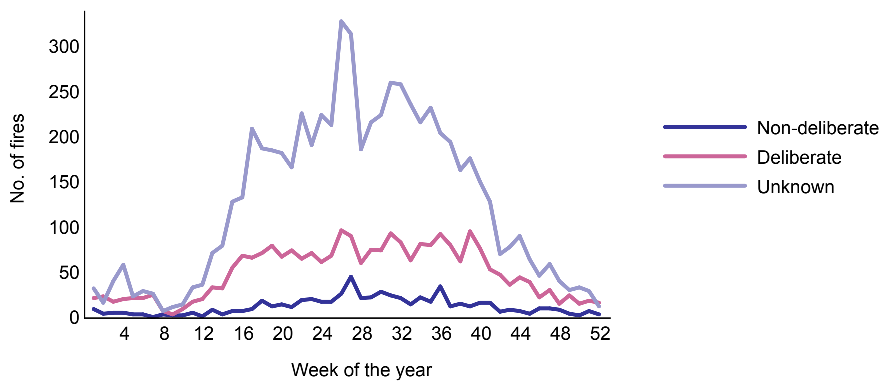
The trends illustrated in Figure 22 are an aggregation of fires from across the state for the same year. The reality is that the arrival of the dry and wet seasons and the predictability of rainfall varied across the territory.

The timing of the bushfire season in the Darwin region was relatively similar across all seasons. Fire numbers increased rapidly at approximately week 17 (late April), commonly peaked mid season, with fire frequencies steadily dropping to negligible levels, particularly from mid October onwards (Figure 23). In contrast, the timing of fires by week of the year in Alice Springs was erratic (Figure 24). The number of fires commonly increased from May to October in 2001 – the cooler months – but in 2002, the number of fires peaked in April and decreased over subsequent months. In all cases, the total fire frequencies were erratic from week to week. In 2002, Alice Springs experienced additional spikes in fire frequencies outside the conventional bushfire danger season, including in January–February. Greater variability in the distribution of fires in the Alice Springs region, as compared with Darwin, may be facilitated by the dryer climate and more erratic rainfall, but may also reflect social differences. For example, there may be fundamentally different reasons that the majority of people in Alice Springs light fires, as compared with Darwin.

The distribution of vegetation fires in the Katherine region differed from that encountered in both Darwin and Alice Springs. In three out of five seasons in Katherine, there was a very rapid increase in the number of fires at the beginning of the bushfire danger season, and on average, the frequency of fires decreased as the season progressed (Figure 25). There was clearly a markedly earlier beginning to the bushfire season in 2002, but the number of fires occurring in any one week did not differ significantly from other seasons. The total number of fires was lower in 2000 and 2004 than in other bushfire danger seasons in the recording period, and the there was no rapid increase in fire frequencies, rather erratic spikes in fire frequency occurred throughout the year (Figure 26).

Accidental fires attributed to children under the age of 16 dominantly occurred during the bushfire season (Figure 27). The greatest number (n=9) occurred during week 27, typically coincident with school holidays.

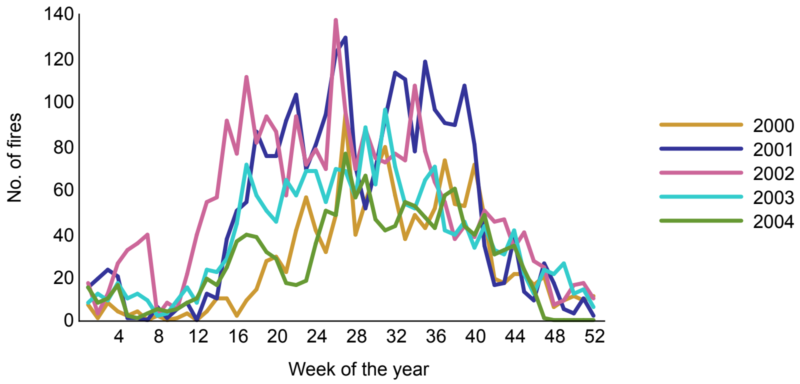
Figure 21: Week of the year[a], by cause (number)



a: week 1 corresponds to the first week of the calendar year

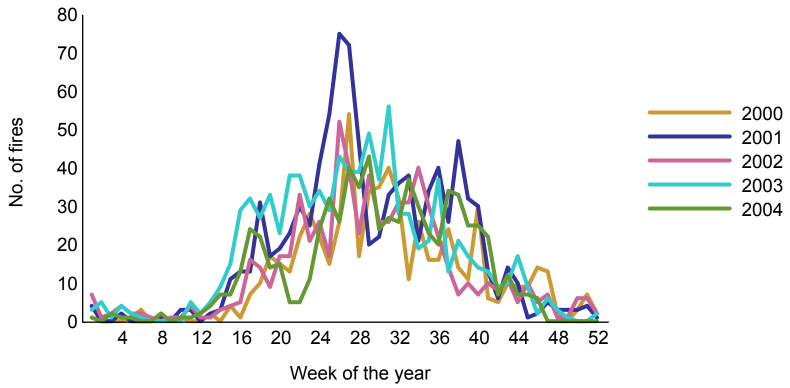
Source: NTFRS 1999–2000 to November 2004 [computer file]

Figure 22: Week of the year (all fires), by year (number)



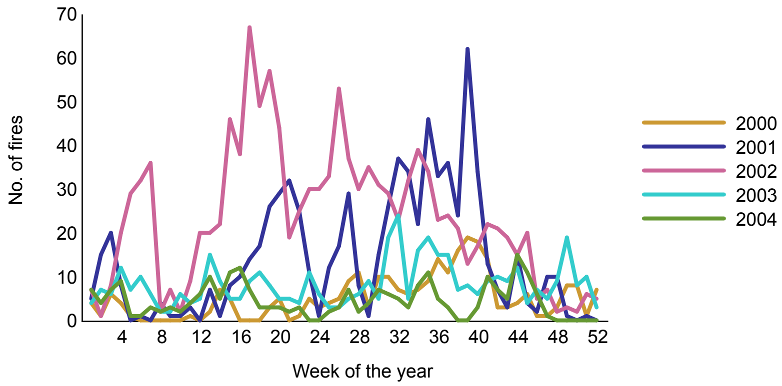
Source: NTFRS 1999–2000 to November 2004 [computer file]

Figure 23: Week of the year (all fires), by year for the Darwin region (number)



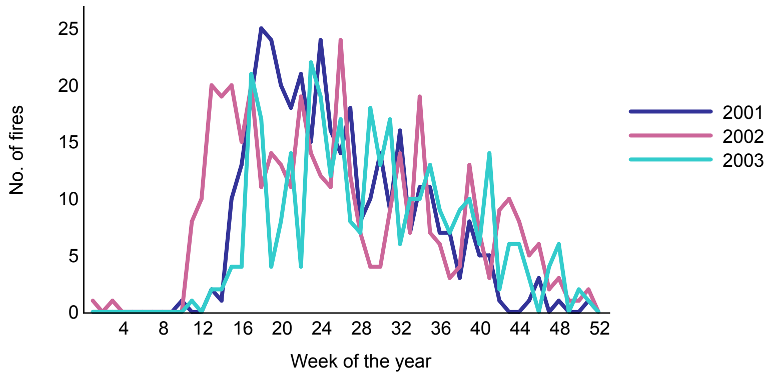
Source: NTFRS 1999–2000 to November 2004 [computer file]

Figure 24: Week of the year (all fires), by year for the Alice Springs region (number)



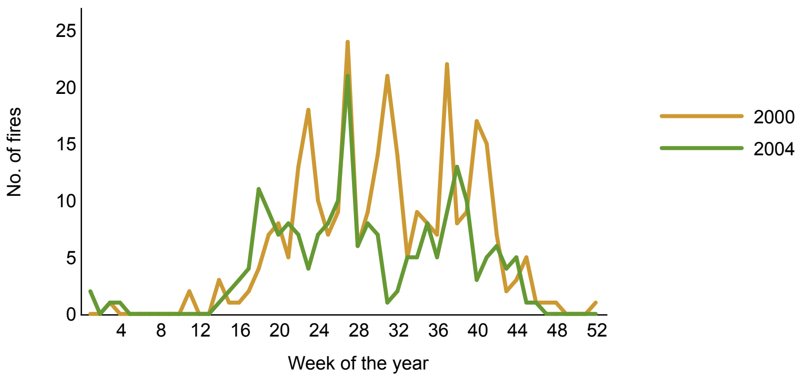
Source: NTFRS 1999–2000 to November 2004 [computer file]

Figure 25: Fires in the Katherine region, by week of the year (all fires) 2001 to 2003 (number)



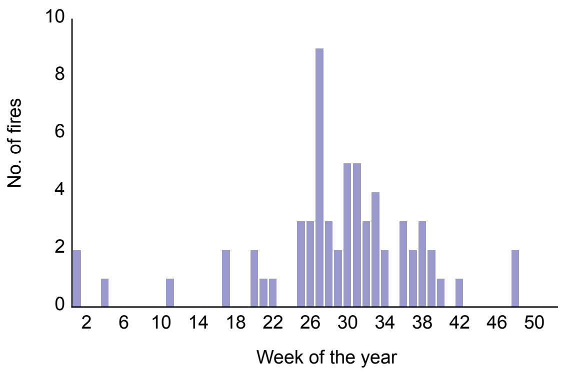
Source: NTFRS 1999–2000 to November 2004 [computer file]

Figure 26: Fires in the Katherine region, by week of the year (all fires) for 2000 and 2004 (number)



Source: NTFRS 1999–2000 to November 2004 [computer file]

Figure 27: Non-deliberate child fires, by week of the year (number)



Source: NTFRS 1999–2000 to November 2004 [computer file]

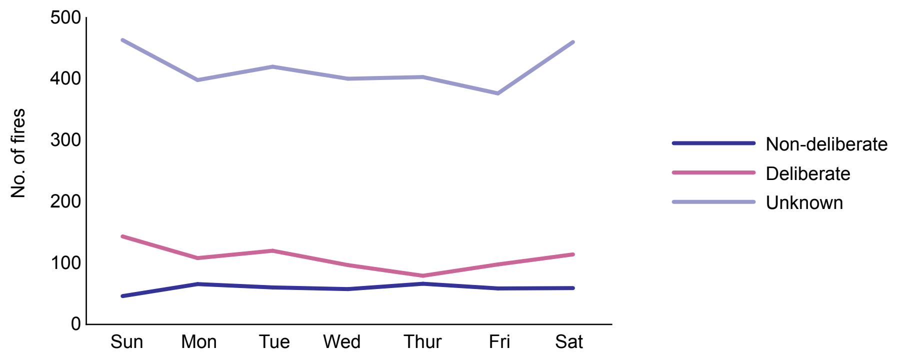
Day of the week

Overall, there was a slight tendency for higher numbers of fires to occur on Saturday and Sunday than on weekdays; the numbers of fires on Sundays were comparable to those observed during the week, whereas fire frequencies on Saturdays were about 14 percent higher than the weekday average.

However, marked differences were observed in the distribution of fires throughout the week across major urban centres in the territory. Darwin was characterised by the most pronounced 'weekend effect', with 13 to 16 percent more fires occurring on both Saturday and Sunday relative to the weekday average. This was reflected for both fires of unknown causes and deliberate causes, but not for non-deliberate fires (Figure 28). In contrast, fire frequencies in Alice Springs increased across the week for both unknown and deliberate causes, but the number of non-deliberate fires remained stable throughout the week (Figure 29). The different patterns observed between Darwin and Alice Springs likely reflected the different social 'timetables' of people within these regions, with fires in Alice Springs being less governed by routines of school or work.

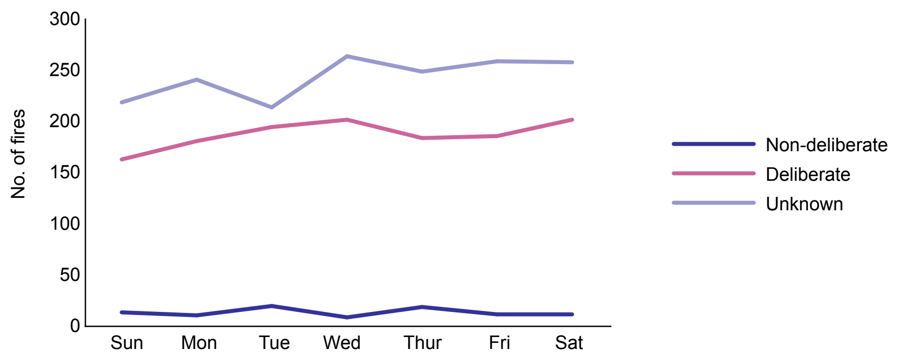
Accidental fires attributed to children younger than 16 years of age were only slightly more frequent on weekends than on weekdays.

Figure 28: Day of the week, by cause, Darwin region (number)



Source: NTFRS 1999–2000 to November 2004 [computer file]

Figure 29: Day of the week, by cause, Alice Springs region (number)



Source: NTFRS 1999–2000 to November 2004 [computer file]

Time of the day

Most vegetation fires occurred between 11 am and 6 pm, but subtle differences were evident depending on the cause of ignition (Figure 30). The number of accidental fires rose sharply between 9 and 11 am, plateau until roughly 7 pm, before sharply declining over the next couple of hours (Figure 30). In contrast, suspicious fires peaked at 6 to 7 pm. The highest incidence of incendiary fires occurred between 7 and 9 pm. It was not uncommon to see a discrepancy between the times at which the highest number of deliberate and non-deliberate fires occurred. However, in both instances the peak number of fires occurred at a slightly later time than in most other jurisdictions.

Approximately 45 percent of all vegetation fires in the territory occurred between the hours of 6 pm and 6 am. This was more notable for incendiary and suspicious causes, where 59 and 52 percent of such fires, respectively, occurred within that timeframe. Approximately, 22 percent of incendiary and 17 percent of suspicious fires occurred between the hours of 10 pm and 4 am.

However, these trends represent an agglomeration of fires from across the territory. In reality the temporal distribution of fires varied markedly between the major urban centres (Figure 31).

In **Darwin**, fire numbers peaked between midday and 8 pm (Figure 31). This trend occurred for non-deliberate, deliberate and unknown fires alike, although the peak in deliberate fires may have been marginally later than for non-deliberate fires (Figure 32). Despite 38 percent of all fires in Darwin occurred between 6 pm and 6 am, only 12 percent occurred between 10 pm and 4 am and there was little evidence for a distinct night-time peak. There was comparatively little difference in the timing of fires in Darwin on different days of the week and there was insufficient data to accurately assess how the timing of deliberate fires differed from that of other causes based on day of the week (Figure 33). Possible trends include:

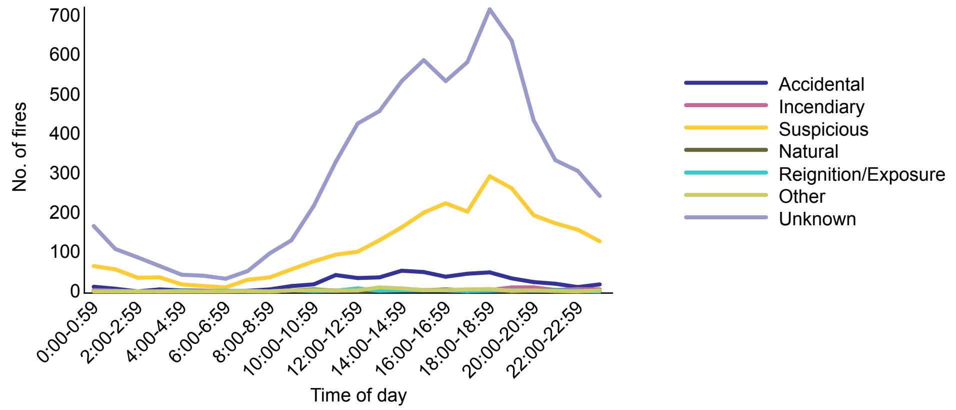
- increased deliberate fires early in the afternoon on Sunday (1 to 4 pm)
- higher frequencies of deliberate fires on Tuesday and Sunday nights between 7 and 9 pm
- lower incidences of deliberate fires after 6 pm on Monday nights
- a distinct late-night peak, at around 11 pm, on Saturday night.

Alice Springs: That there were different ‘timetables’ for people who lit fires in Alice Springs and Darwin was clearly reflected in the different timings of vegetation fires in these regions (Figure 31). In Alice Springs the total vegetation fire frequencies increased slowly throughout daylight hours, rose sharply between 6 and 7 pm, sharply decreased between 8 and 9 pm, and declined throughout the night, reaching a minimum at around 6 am. This general pattern occurred for both deliberate and unknown fires, but was not evident for non-deliberate fires, implying that many of the fires classified as deliberate or unknown have a common origin. This general pattern occurred on most days of week (with subtle variations) with the exception of Sunday, when generally lower fire frequencies were reported from 5 pm onwards (Figure 34). The large spike in fire frequencies between 6 and 9 pm is consistent with a high frequency of fires pertaining to domestic activities, including fires that are used for both cooking and warmth during the winter months.

If this was the case, it not then surprising that approximately 60 percent of all fires in the Alice Springs region occurred between the hours of 6 pm and 6 am. Twenty percent of all fires occurred between 10 pm and 4 am. The lack of any substantive increases in deliberate fires on Friday night–Saturday morning and Saturday night–Sunday morning is consistent with the lack of increased numbers of fires in Alice Springs on weekends generally.

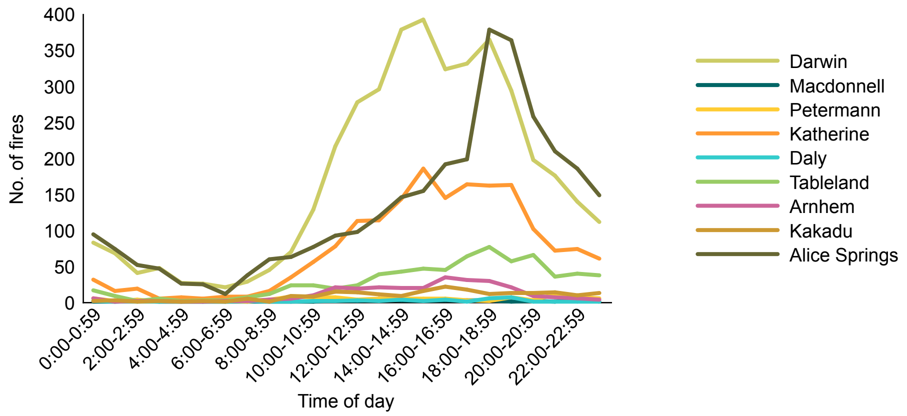
Other areas: Peak frequencies of fires in Katherine and the Tablelands occurred at 4 to 7 pm and 6 to 10 pm respectively. The timing of fires in the Tablelands regions appears to be most similar to that occurring in the Alice Springs region.

Figure 30: Time of day, by cause (number)



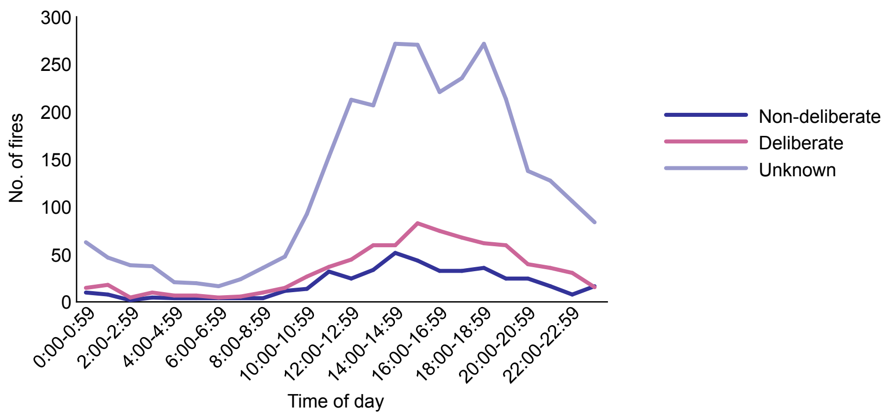
Source: NTFRS 1999–2000 to November 2004 [computer file]

Figure 31: Time of day, by region (number)



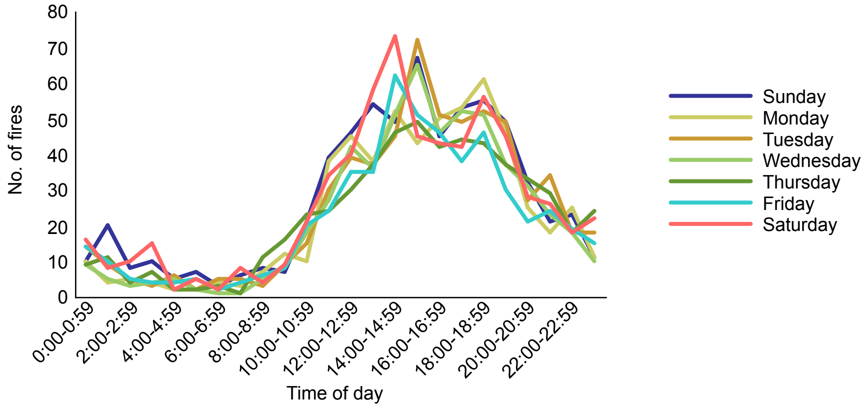
Source: NTFRS 1999–2000 to November 2004 [computer file]

Figure 32: Time of day, by cause for the Darwin region (number)



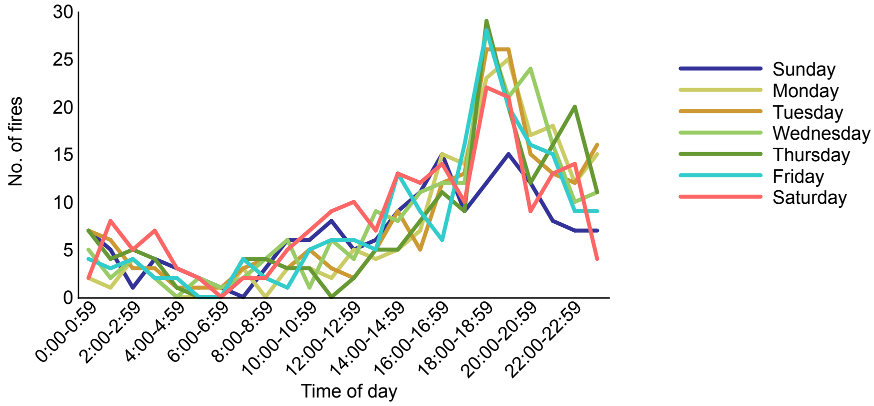
Source: NTFRS 1999–2000 to November 2004 [computer file]

Figure 33: Time of day, by day of the week, for fires (all causes) in the Darwin region (number)



Source: NTFRS 1999–2000 to November 2004 [computer file]

Figure 34: Time of day, by day of the week, for deliberate fires in the Alice Springs region (number)



Source: NTFRS 1999–2000 to November 2004 [computer file]

Area burned

Data pertaining to the area burned was available for 49 percent of fires. Overall, the number of fires of a given size decreased with increasing area burned (Figure 35); 90.5 percent of all fires were less than one hectare, and 96.6 percent of fires were less than 10 ha.

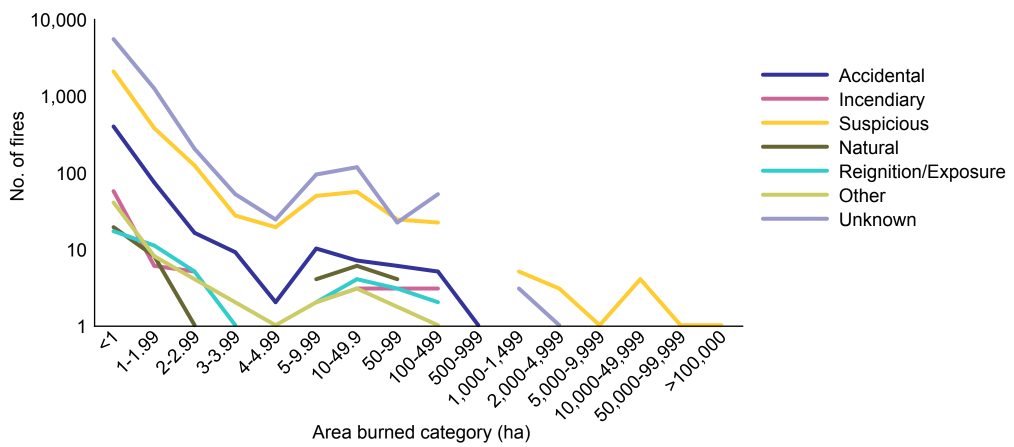
There appears to be a relationship between the frequency of a particular fire cause and the 'likelihood' that it exceeded a certain size; that is, the greater the frequency of that cause overall, the greater the number of larger fires (Figure 35). With the exception of one accidental fire resulting from the inadequate control of an open flame that burned 25,000 ha and one fire resulting from the re-kindling of a previous fire which burned 2,000 ha, all fires of 'known' cause burning in excess of 500 ha were suspicious in origin. The distribution of fires in the Northern Territory differs subtly from that observed in most other jurisdictions, as the proportion of deliberate fires within an area burned category actually increased (as opposed to decreased) within increasing area burned (Figure 36). This may reflect the fact that this database does not include many of the large natural fires and prescribed burns that occurred throughout the territory.

Approximately 1,068,870 ha burned in NTFRS-attended fires between July 1999 and November 2004. The overwhelming majority of this area was burned in 2000 (Figure 37). During this year two fires, one deliberate (classified suspicious) and one of unknown cause, burned 400,000 and 500,000 ha respectively. These two fires dominate the statistics pertaining to the area burned by specific causes. Notably, deliberate fires accounted for 49 percent of the total area burned (Figure 38). The total area burned by deliberate fires continued to decrease since 2000. The proportion of total area burned by deliberate fires also decreased, from 50 and 90 percent in 2000 and 2001 respectively, to less than 10 percent from 2002 to 2004 (incomplete).

Some caution is required in extrapolating the trends defined by the NTFRS data due to the situation in the Northern Territory at large. In fact, the NTFRS area burned data is unlikely to bear much resemblance to territory-wide trends during the same interval. For example, more than 80 percent of the total area burned in NTFRS-controlled areas occurred in the two greater than 100,000 ha fires in the Tablelands region during 2000, giving the appearance that 2000 was the most significant fire year. However, 38,000,000 ha burned in the territory in 2002 (Ellis, Kanowski & Whelan 2004). While not as extensive, the NTFRS subset of fires are important from the perspective that these fires occurred in close proximity to residential or other urban spaces.

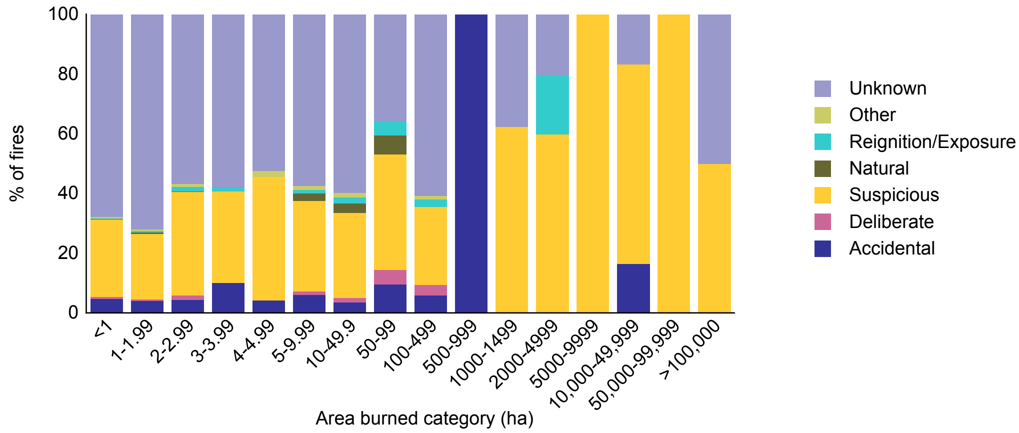
Although the size distribution of fires within individual regions typically followed the trends observed in Figure 36, it is noted that fires occurring in the Darwin, Alice Springs and Katherine regions were comparatively small, with the largest fires in each of these regions being 2,000, 1,000 and 300 ha respectively (Figure 39). Fires in the Alice Springs and Katherine regions accounted for a decreasing proportion of NTFRS fires within each category as fire size increased. The majority of large fires (1,000 ha or more) occurred in the Tablelands region, including the only fires to exceed 100,000 ha.

Figure 35: Area burned category, by cause (number)



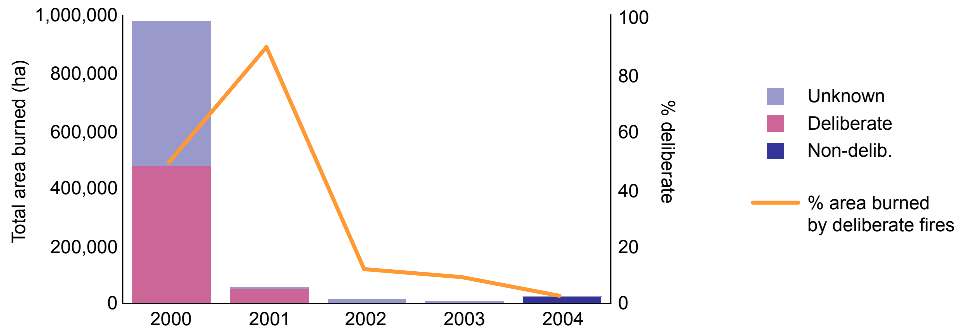
Source: NTFRS 1999–2000 to November 2004 [computer file]

Figure 36: Area burned category, by cause (percent)



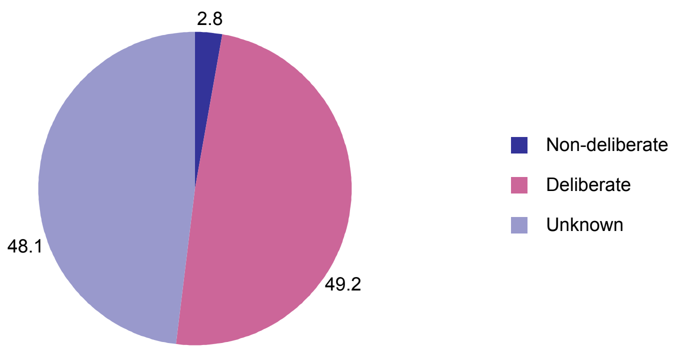
Source: NTFRS 1999–2000 to November 2004 [computer file]

Figure 37: Area burned each year, by cause



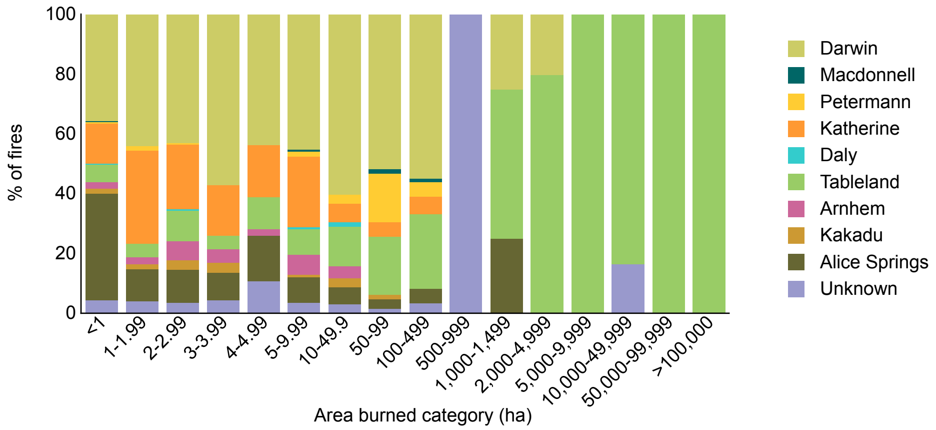
Source: NTFRS 1999–2000 to November 2004 [computer file]

Figure 38: Area burned, by cause (percent)



Source: NTFRS 1999–2000 to November 2004 [computer file]

Figure 39: Area category, by cause (percent)

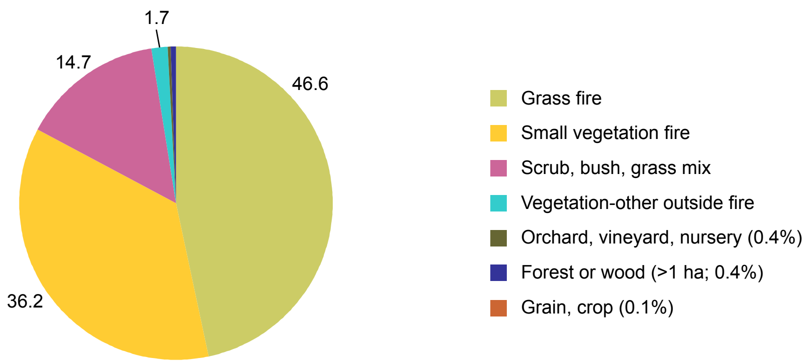


Source: NTFRS 1999–2000 to November 2004 [computer file]

Type of incident

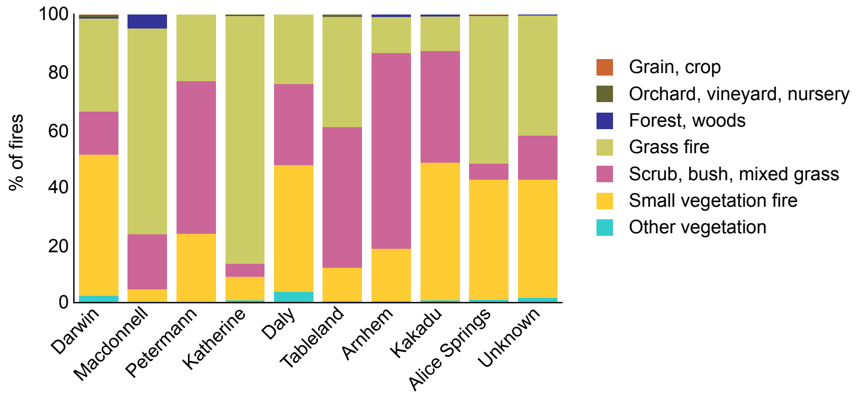
Almost 47 percent of the vegetation fires the NTFRS attended were grass fires with a further 36 percent being small vegetation fires less than one hectare (Figure 40). Another 15 percent occurred in mixed bush, scrub and grass settings. Only 0.4 percent of fires occurred in forests or woodland. Small vegetation fires comprised between one-third and one-half of all vegetation fires in the Darwin, Daly, Kakadu, and Alice Springs regions (Figure 41). Grassfires where the dominant type of incident in both the Katherine and Macdonnell regions, whereas mixed scrub/bush/grass fires featured more strongly in the Petermann, Tableland, Arnhem and Kakadu regions. Other types of fire incidents comprised small or negligible percentages of vegetation fires in all regions. Given the above, it is not surprising that the overwhelming majority of fires occurred in vegetation types classified as either savannah or grassland, where the vegetation type was identified in the database (62.3% of cases; Figure 42).

Figure 40: Incident type (percent)



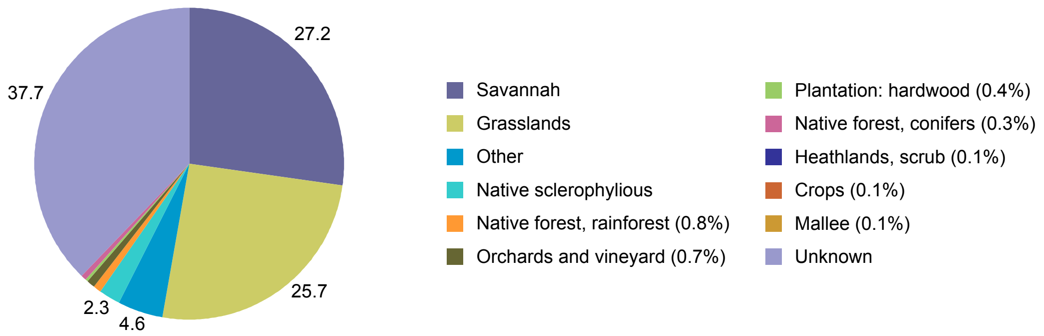
Source: NTFRS 1999–2000 to November 2004 [computer file]

Figure 41: Region, by incident type (percent)



Source: NTFRS 1999–2000 to November 2004 [computer file]

Figure 42: Fires in each vegetation type (percent)



Source: NTFRS 1999–2000 to November 2004 [computer file]

Factors impacting on NTFRS fire frequencies

The NTFRS has subsequently undertaken a number of initiatives to reduce the overall incidence of vegetation fires in areas within their jurisdiction. Hazard abatement has included hazard reduction burns on Crown lands, enforcement of firebreak legislation, encouragement of rural landowners to reduce the fuel loading on the properties through face-to-face meetings, community forums at the commencement of the fire season and a combined approach to fire reduction by both the NTFRS and Bushfires NT. The benefits of this approach are seen as effectively changing the community's cultural attitude towards fire in the territory. This is considered the prime reason for the reduction from 3,400 vegetation fire per annum four or five years ago to just 1,300 in 2005–06 (NTFRS, personal communication).

Another key initiative has been development of partnerships between fire agencies, the local town council, Indigenous groups and other government agencies to specifically address issues about problematic fires in Indigenous communities. Note that this does not include 'comfort fires'. In acknowledging the unique cultural importance of fire in Indigenous communities the Northern Territory Fire and Emergency Act permits use of small fires for cooking and for keeping warm on cold nights (outside of periods of fire bans or fire warning); no permit to burn is required by anyone to light a comfort fire.

Summary

The most important points regarding urban vegetation fires in the Northern Territory are summarised below:

- The NTFRS attended 10,650 vegetation fires from July 1999 to November 2004; the highest frequency of vegetation fires occurred in 2002, followed by 2001.
- Twenty-seven percent of vegetation fires were deliberate (0.7% incendiary; 25.8% suspicious), with the cause of 67.2 percent of fires being unknown. Hence, deliberate fires comprised 81 percent of known causes. The percentage of deliberate fires annually remained uniform.
- Thirty-eight percent of all vegetation fires NTFRS attended occurred in Darwin; 39 percent were in Alice Springs with a further 17 percent in Katherine. Variations in the percentage of deliberate vegetation fires largely occurred between regions (2 to 70%) principally reflected differing levels of causal attributions.
- There was no direct correlation between the total number of vegetation fires or number of deliberate vegetation fires and population. The incidence of fires ranged between one and 380 fires per 10,000 fires per year, with four postcodes in the Tablelands, Katherine, Alice Springs and Darwin regions recording the highest rates.
- Vegetation fires principally occurred from March to October. However, the timing of increases in fire frequencies at the beginning of the dry season was less systematic than the decrease in vegetation fire numbers at the beginning of the wet season. The timing (week of the year) of vegetation fires was highly predictable in Darwin (close to the coast) but very unpredictable in Alice Spring (far from the coast). The distribution of fires throughout the season varied subtly between bushfire season in the Darwin, and to a lesser extent Katherine region, but varied markedly for Alice Springs.
- Substantive differences, based on the day of week and detection time that vegetation fires occurred, were apparent between urban centres. In the Darwin region vegetation fires were 13 to 16 percent more prevalent on both Saturday and Sunday, with the majority of fires occurring between midday and 8 pm. In Alice Springs, vegetation fires were not more likely to occur on a weekend, and the fire numbers peaked between 7 and 8 pm. Notably, 60 percent of vegetation fires in Alice Springs occurred between 6 pm and 6 am with 20 percent of all vegetation fires occurring between 10 pm and 4 am. Subtle variations also occurred between the timing of vegetation fires in other centres.
- Marked differences in the distribution of vegetation fires in Darwin and Alice Springs likely reflect fundamentally different social patterns and possibly the dominant purposes of fire in these regions.
- The types of incidents attended included grassfires (47%), small vegetation fires (36%) and mixed scrub/bush/grass fires (15%).
- During the observation period 1,068,870 ha were burned in NTFRS vegetation fires, principally reflecting contributions from two large fires in the Tablelands region.
- Ninety percent of vegetation fires were less than one hectare; fires of suspicious origin were the principal known cause of fires in excess of 500 ha. Deliberate fires accounted for half of the total area burned. Fires of unknown cause burned the majority of the remainder.
- Specific ignition factors are summarised as:
  - Subtle differences were evident in the most predominant form of heat of ignition between deliberate and non-deliberate vegetation fires. Most smoking-related fires were non-deliberate, whereas 70 to 80 percent of vegetation fires attributed to matches and lighters were either incendiary or suspicious in origin.
  - Less than three percent of vegetation fires were identified as smoking related.
  - Non-deliberate fires started by children 16 years and younger accounted for 0.6 percent of all vegetation fires. Almost three-quarters of these occurred in the Darwin region.

Sources of background information

ABS 2006. *Australian demographic statistics*. ABS cat. no. 3101.0. http://www.abs.gov.au/ausstats/abs@.nsf/cat/3101.0

ABS 2005a. *Population by age and sex, Northern Territory Australia*. ABS cat. no. 3235.7.55.001. http://www.abs.gov.au/ausstats/abs@.nsf/cat/3235.7.55.001

ABS 2005b. *Tourism region maps and concordance files, Australia, 2005*. ABS cat. no. 9503.0.55.001. http://www.abs.gov.au/ausstats/abs@.nsf/cat/9503.0.55.001

Australia. Department of Environment and Heritage 2001a. *Land use: Northern Territory*. Accessed through: http://audit.deh.gov.au/ANRA/atlas_home.cfm

Australia. Department of Environment and Heritage 2001b. *Native vegetation types and extent: Northern Territory*. Accessed through: http://audit.deh.gov.au/ANRA/atlas_home.cfm

Australian Bureau of Meteorology 2007a. *Average minimum and maximum temperature maps: Northern Territory*. Accessed through: http://www.bom.gov.au/climate/map/temperature/IDCJCM0005_temperature.shtml

Australian Bureau of Meteorology 2007b. *Average rainfall, annual: Northern Territory*. Accessed through: http://www.bom.gov.au/cgi-bin/climate/cgi_bin_scripts/annual-monthly-rainfall.cgi

Dyer R et al. 2001. *Savanna burning: understanding and using fire in northern Australia*. Darwin: Tropical Savannas CRC

Ellis S, Kanowski P & Whelan R 2004. *National Inquiry into Bushfire Mitigation and Management*. Canberra: Commonwealth of Australia. http://www.coagbushfireenquiry.gov.au/findings.htm

Hughes C. 1994. Fire management in the Northern Territory post-Mabo: the legal basis for Aboriginal burning. In D Rose (ed), *Country in flames: proceedings of the 1994 symposium on biodiversity and fire in North Australia*. Biodiversity series, paper no. 3. Biodiversity Unit, Department of the Environment, Sport and Territories and the North Australia Research Unit, ANU. http://www.environment.gov.au/biodiversity/publications/series/paper3/fire8.html

NAFI 2007. *North Australia fire information 2007*. http://www.firenorth.org.au/nafi/app/init.jsp

NRETA 2006a. *Bushfires NT: bushfire operations*. http://www.nt.gov.au/nreta/naturalresources/bushfires/

NRETA 2006b. *Bushfires NT: bushfire research*. http://www.nt.gov.au/nreta/naturalresources/bushfires/research/desertfire.html

NTFRS 2006. *Our people*. http://www.pfes.nt.gov.au/index.cfm?fuseaction=page&p=272&m=37